

COVID-19 in children and the role of school settings in COVID-19 transmission

6 August 2020

Key messages

- A small proportion (<5%) of overall COVID-19 cases reported in the EU/EEA and the UK are among children (those aged 18 years and under). When diagnosed with COVID-19, children are much less likely to be hospitalised or have fatal outcomes than adults.
- Children are more likely to have a mild or asymptomatic infection, meaning that the infection may go undetected or undiagnosed.
- When symptomatic, children shed virus in similar quantities to adults and can infect others in a similar way to adults. It is unknown how infectious asymptomatic children are.
- While very few significant outbreaks of COVID-19 in schools have been documented, they do occur, and may be difficult to detect due to the relative lack of symptoms in children.
- In general, the majority of countries report slightly lower seroprevalence in children than in adult groups, however these differences are small and uncertain. More specialised studies need to be performed with the focus on children to better understand infection and antibody dynamics.
- Investigations of cases identified in school settings suggest that child to child transmission in schools is uncommon and not the primary cause of SARS-CoV-2 infection in children whose onset of infection coincides with the period during which they are attending school, particularly in preschools and primary schools.
- If appropriate physical distancing and hygiene measures are applied, schools are unlikely to be more effective propagating environments than other occupational or leisure settings with similar densities of people.
- There is conflicting published evidence on the impact of school closure/re-opening on community transmission levels, although the evidence from contact tracing in schools, and observational data from a number of EU countries suggest that re-opening schools has not been associated with significant increases in community transmission.
- Available evidence also indicates that closures of childcare and educational institutions are unlikely to be an effective single control measure for community transmission of COVID-19 and such closures would be unlikely to provide significant additional protection of children's health, since most develop a very mild form of COVID-19, if any.
- Decisions on control measures in schools and school closures/openings should be consistent with decisions on other physical distancing and public health response measures within the community.

VISIT...

LANZAROTE
Caliente.COM

Glossary

The school structures within the EU/EEA Member States and UK are heterogeneous, with children entering and moving through educational establishments at different ages [3]. Given this variation, it is not possible to define the age of attendance in EU education establishments with full consistency. Therefore, for the purposes of this document, the following classification has been used:

Preschools	Establishments including childcare and daycare centres, nurseries and kindergartens for children under five years of age, although these may include older children in some EU settings.
Primary schools	Establishments providing early-years compulsory education, which in most EU settings include children aged 5–11 years.
Secondary schools	Education establishments for children aged 12–18 years.
Schools	The generic term used to define all educational establishments within the scope of the document, and it can be inferred that this includes all three categories of schools referred to above, unless otherwise stated.
Staff	Includes teachers, administrators and management, school nurses, janitors, cleaning and kitchen personnel, and other adults working in childcare and educational settings.

Scope of this document

The aim of this document is to provide an overview of the epidemiology and disease characteristics of COVID-19 in children (0–18 years) in EU/EEA countries and the United Kingdom (UK), and an assessment of the role of childcare (preschools; ages 0–<5 years) and educational (primary and secondary schools; ages 5–18 years) settings in COVID-19 transmission.

Target audience

The target audience for this report is public health authorities in EU/EEA countries and the UK.

Background

Although fewer than 5% of COVID-19 cases reported in EU/EEA countries and the UK have been in persons under 18 years of age, the role of children in SARS-CoV-2 transmission remains unclear, especially in the context of educational settings. Available evidence to date indicates that children most probably contract COVID-19 in their households or through contact with infected family members, particularly in countries where school closures and strict physical distancing has been implemented [4,5].

Following the declaration of COVID-19 as a global pandemic in early March, many EU/EEA countries and the UK began to close schools to limit the spread of the virus, despite limited evidence as to whether childcare and educational settings play a role in transmitting SARS-CoV-2. These decisions were based on what is known of the impact of pre-emptive early school closures on transmission of pandemic influenza. In recent months, Member States have adjusted policies on schools as the pandemic has progressed.

In week 9 (9–15 March), 42% (13/31) of EU/EEA countries and the UK had closed preschools, 64% (20/31) primary schools, and 48% (15/31) (Figure 1).

By week 17 (20–26 April) 2020, 80% (25/31) of EU/EEA countries and the UK had fully or partially closed preschools, 90% (28/31) had closed primary schools and 100% had closed secondary schools or higher education establishments (31/31).

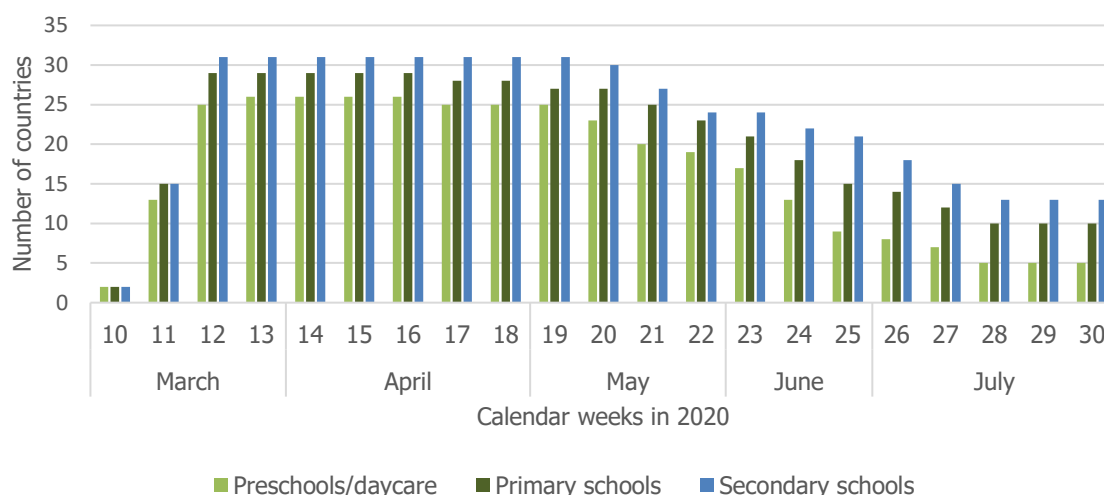
From mid-May, following reduction in the number of COVID-19 cases and/or deaths, EU/EEA countries started to partially re-open schools. In the week beginning 18 May (week 21) 20 countries (65%) reported closure of preschools and 25 (80%) reported closure of primary schools; respectively five and three countries less than the previous month.

From mid-June, EU/EEA countries had removed closure notices in the majority of preschool and primary schools and in the week beginning 15 June (week 25) closures were in place in only nine (29%) and 15 (48%) countries respectively, but secondary school closures remained in place in 21 countries (68%). Irrespective of their policies on closure, by this time schools in many European countries had started summer holidays (exact dates vary across and within countries).

As of week 30 (20–26 July), 67% (21/31) EU/EEA countries and the UK had reopened their primary schools and preschools at least partially, although in many settings, school summer holidays were still ongoing.

Four Member States (Estonia, Finland, Iceland and Sweden) never closed preschools and only two never closed primary schools (Iceland and Sweden) (Annex 1).

Figure 1. Total number of EU/EEA countries and the UK (N=31) that enacted some form of school closure during the pandemic¹



¹Totals are the sum of countries that had any form of school closure or restrictions in place at each specific point in time, including those with only partial closures in place.

Approaches to school closures have varied in most Member States with some schools enacting partial measures. Various policy approaches have been deployed that can be termed as 'partial closure', particularly during the recent phases of the pandemic when many countries were reducing societal intervention and reopening schools. 'Partial' measures taken include restricting class sizes, opening schools only for specific age/year groups, organising lessons with staggered timetables or alternating student cohorts between remote and in-school teaching [8].

A number of other non-pharmaceutical interventions (NPI) have been used as measures to reduce the risk of SARS-CoV-2 transmission in school settings where schools have been open, with the aim of decreasing the number of people in the school building, and/or decreasing the probability of infectious cases participating in school activities. These measures include basic advice to maximise physical distancing (supported by partial school closures in many cases), and encouragement/regulations for sick students, teachers and staff to stay home. Some countries in which schools had been closed also prepared detailed plans and guidance for their re-opening, Belgium and the United Kingdom being two such examples. A summary of NPI approaches used, including specific examples of action taken by individual Member States, is presented in Annex 2.

Under the European legislative framework on occupational safety and health (OSH), employers have an obligation to develop a prevention policy and ensure a safe and healthy workplace [10]. Many national and international organisations have published guidance on the organisation of schools to address risks from COVID-19, including WHO and several EU/EEA Member States and the UK. Examples are listed in Annex 3. In addition, the European Agency for Safety and Health at Work (EU-OSHA) has compiled guidance documents from different countries on COVID-19 and the educational sector [11].

The effect of school closures on the transmission of SARS-CoV-2 in the EU/EEA/UK and globally is largely unknown, but the effect of school closures on children's health and well-being has been well-documented and researched over the years, following influenza pandemics and school closures during the summer months.

Impact of school closures on the health and well-being of children

A number of organisations have identified various negative impacts on children's wellbeing, learning opportunities and safety caused by school closures [12-14]. These range from the interruption of learning and the exacerbation of disparities and mental health issues to an increased risk of domestic violence. The negative impacts particularly affect children from vulnerable and marginalised population groups.

A report from the European Network of Ombudspersons for Children (ENOC) and the United Nations International Children's Fund (UNICEF) [13] indicates that children living in precarious conditions, and/or from ethnic minorities have faced more difficulties with distance learning, both due to digital poverty and difficulties for parents being able to assist in the learning process.

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) [14] highlights that when schools close, children and youth are deprived of opportunities for growth and development. These disadvantages are disproportionate for under-privileged learners who tend to have fewer educational opportunities beyond school. Furthermore, economic circumstances can jeopardise the return to school for children and young people who are under pressure to work and generate income for financially distressed families.

Other health aspects, both physical and mental, also need consideration. For many students living in poverty, schools are not only a place for learning, but also for healthy eating, and therefore researchers warn that school closures will exacerbate food insecurity [15]. Research has highlighted that the active social life that children aged 2–10 years have at school helps them to learn from peers and has a positive impact on their personality and sense of identity, while disruptions of close peer relationships have been associated with depression, guilt, and anger in children [16]. Furthermore, school and extracurricular activities provide structure, meaning and a daily rhythm for children and youth. For those suffering from anxiety and depression, the loss of such activities can worsen symptoms and reinforce social withdrawal and feelings of hopelessness [17].

The report from ENOC and UNICEF also highlights other consequences of school closures [13]. Children with disabilities may be particularly affected as they can feel more isolated when schools and special services are closed and they have limited possibilities for digital communication. In addition, more time spent online increases the risk of cyber-bullying.

Furthermore, children are at increased risk of domestic violence during periods of school closure associated with health emergencies [18]. With schools closed, children no longer have a safety net that can detect and report child abuse, as well as an external social network and the support for coping with abuse at home. Beyond short-term effects, child-abuse and neglect have long-term effects, including mental health disorders, sexually transmitted infections, unwanted pregnancies, and substance abuse [19].

Methodological approach

This technical report provides an overview of the epidemiology and disease characteristics of COVID-19 among children, and an assessment of the role of childcare school settings in COVID-19 transmission.

To address the epidemiology and disease characteristics of COVID-19 in children, a summary of evidence was produced, based on analysis of data from two different sources:

- Case-based epidemiological data from The European Surveillance System (TESSy);
- Data from the scientific literature that focuses on disease characteristics of COVID-19 with a focus on the population aged 18 years or younger. Searches were conducted to collect and to provide an overview of the latest available evidence on COVID-19 disease background in children, covering the following aspects: symptoms, severity, complications, viral shedding, infection, transmission, immune response and immunity.

To address the possible role of school settings in driving community transmission, information was gathered from literature searches and a survey with follow-up calls.

1. Literature searches

These took the form of daily literature searches conducted by ECDC to collect the latest available publications on COVID-19. The ECDC COVID-19 EndNote reference library contains more than 40 000 records and is updated and maintained by the ECDC Library. The EndNote library is updated daily, with results of a saved search designed to retrieve all new publications related to COVID-19 in PubMed, which is complemented by the monitoring of journal websites, COVID-19 specific publishers' portals for new publications and preprint portals for upcoming publications.

A more detailed description of the search is described in Annex 4. Articles were screened for relevance to school settings specifically and were included or excluded based on the criteria described in Annex 4. Additional articles were considered for relevance if they were published while the review was ongoing, so that the latest evidence could be included. The search was performed on 30 June 2020 and in total, 59 articles were retrieved.

2. Survey and follow-up calls

A two-question survey was distributed by email in July 2020 to the 31 ECDC Operational Contact Points for Influenza and COVID-19, as well as the countries' National Focal Points (NFPs) for Influenza, NFP for Surveillance, NFPs for Preparedness and Response and the National Coordinators. The questions were:

- Have there been any outbreaks of COVID-19 in educational settings in your country?
If yes, have you undertaken any investigations in relation to these outbreaks?
- Do you have any indications of transmission from children to adults in educational settings or in general (e.g. from household studies or contact tracing)?

Follow-up phone calls were arranged with a subset of the responding countries to provide further clarifications and informal discussions individual country experiences.

The draft report was circulated to all EU/EEA countries and the UK in order to provide the opportunity to validate country data and its interpretation.

Results

Epidemiology and disease characteristics of COVID-19 in children

As of 26 July 2020, children made up a very small proportion of the 744 448 cases reported to TESSy as case-based data in the EU/EEA and in the UK; 31 380 (4%) were children aged under 18 years. Of these, 7 044 (24% of children) were below five years of age, 9 645 (32%) between five and 11 years and 13 020 (44%) between 12 and 18 years.

The age distribution of cases observed in the EU/EEA and the UK reflects testing policies and case definitions, which usually include the presence of symptoms. It is possible that the small proportion of cases reported among children reflects a lower risk of children developing COVID-19 symptoms or the fact that children are generally not prioritised for testing as they commonly experience milder symptoms. There might also be a lower tolerability/acceptance for testing children, given the invasiveness of nasopharyngeal swabbing.

Pooled and country-specific TESSy data are available in an online report series, published weekly on the ECDC website: <https://covid19-surveillance-report.ecdc.europa.eu/>.

Common signs and symptoms in children

COVID-19, like SARS and MERS, is observed less frequently in children, who tend to present milder symptoms and have a better overall outcome than adults [20-24]. The most commonly reported symptoms in children are fever and cough [21,22,25]. Other symptoms include gastrointestinal symptoms, sore throat/pharyngitis, shortness of breath, myalgia, rhinorrhoea/nasal congestion and headache, with varying prevalence among different studies [21,22,25,26].

In a cohort of 582 paediatric cases of SARS-CoV-2 infection from 21 European countries, signs and symptoms upon presentation at healthcare institutions included fever (pyrexia) (65%), upper respiratory tract infection (54%), headache (28%), lower respiratory tract infection (25%) and gastrointestinal symptoms (22%) [27]. Correspondingly, studies from Italy [4,5,28,29], Germany [30], UK [31], Turkey [32] and Sweden [33] described similar symptoms and reported fever and cough as the most commonly observed symptoms. Gastrointestinal symptoms were more prevalent in children with severe COVID-19 than in those with mild disease [34].

Asymptomatic infection in children has been described in several large case series from China, which reported 4% to 28% asymptomatic paediatric cases among cases tested based on symptoms, signs or contact tracing [35,36]. A recent systematic review presenting data on 2 914 paediatric patients with COVID-19 from China, Spain, Iran, the Republic of Korea and the United States identified 14.9% asymptomatic cases in children [22]. Others have reported 18% asymptomatic cases in a meta-analysis of 551 laboratory-confirmed cases in children [37] and 16% asymptomatic cases among a European cohort of 582 children [27]. Similar observations were made for infants and neonates, 16% of whom were asymptomatic in a review of 160 infants with confirmed COVID-19 [25].

One explanation for why children might have milder symptoms of COVID-19 than adults is that children have a much more effective innate immune response than adults or elderly people. The observation of virus transmission by asymptomatic cases is strengthening the scientific evidence that the highly effective innate immune response against viruses, such as in children, provides a sufficient suppression of virus replication to prevent the development of COVID-19 specific symptoms [38].

Another explanation for milder symptoms in children is the possibility of cross-immunity against SARS-CoV-2 developed through previous seasonal coronavirus infection. The evidence regarding cross-immunity from prior seasonal coronavirus infection and anti-SARS-CoV-2 antibody levels is conflicting [39,40].

Severity and complications

Among children reported by EU/EEA countries and the UK to TESSy, the proportion of cases hospitalised were lowest in the age groups 5–11 years and 12–18 years (3% and 4% respectively) and highest among 0–4 year olds (10%). Among adults, the proportion of hospitalised cases increased with age and was highest among 70–79 and 80–89 year olds (39% and 35% respectively) (Figure 2a). Deaths among cases under 18 years were extremely uncommon; only six out of a total of 19 654 (0.03%) deaths reported in TESSy were among children (for countries reporting complete data on outcome). This corresponds to a crude case-fatality of 0.03% among those aged under 19 years, compared to 5.8% among those aged 18 years and above, driven largely by deaths in cases aged 60 years and above, where case-fatality rates increase to 36% among those aged 90 years or above (Figure 2b). In weekly monitoring of all-cause mortality in 24 participating European countries or regions, mortality among 0–14 year olds has not exceeded background rates, in stark contrast to the significant excess mortality among the older adult age groups [41].

Figure 2a. Proportion of hospitalised COVID-19 cases by age group, TESSy, EU/EEA and UK, 26 July 2020

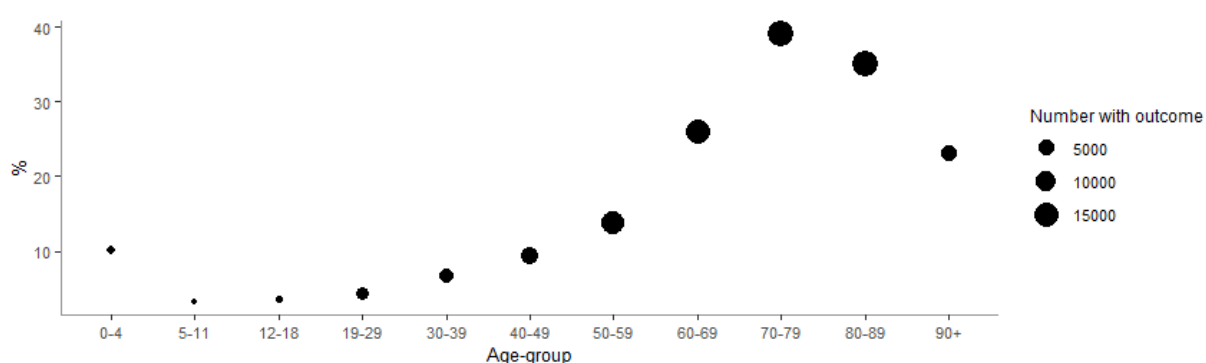
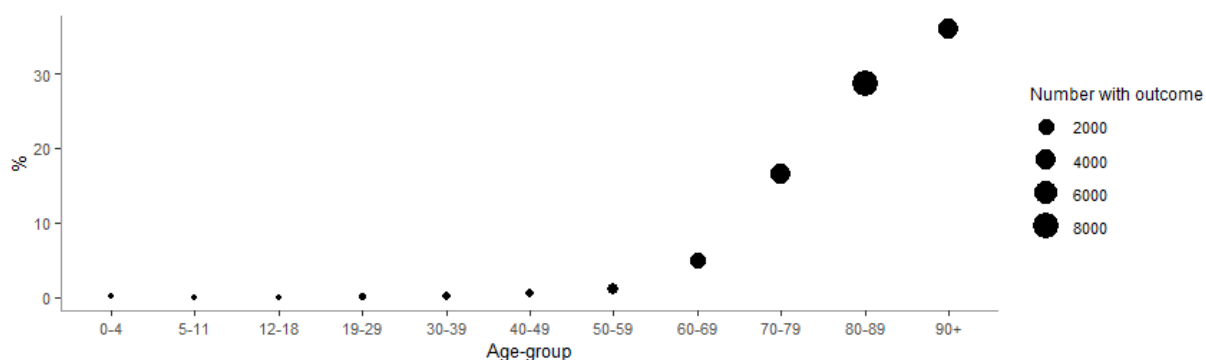


Figure 2b. Crude case fatality rate by age group among all notified COVID-19 cases, TESSy, EU/EEA and UK, 26 July 2020



Severe or critical illness has been reported among 2.5% to 5% of paediatric cases from China [35,42], and more recently, 4% of cases were reportedly as severe or critical in a systematic review [43] and meta-analysis [21] of 4 857 and 2 855 children, respectively. Infants and neonates were described as more vulnerable to severe COVID-19 than other paediatric groups in recent literature reviews [22,25,44], although in most cases a low mortality rate (0.006%) with favourable outcomes was reported for this group [25,27].

Pre-existing medical conditions have been suggested as a risk factor for severe disease and ICU admission in children and adolescents [26,27].

Several countries affected by the COVID-19 pandemic reported cases of children who were hospitalised in intensive care units due to a rare paediatric inflammatory multisystem syndrome (PIMS) or multisystem inflammatory syndrome in children (MIS-C) [45-47], characterised by a systemic disease involving persistent fever, inflammation and organ dysfunction following exposure to SARS-CoV-2 [48-50]. For further information on PIMS in SARS-CoV-2

patients, please refer to the ECDC rapid risk assessment [51]. Paediatric patients have also been reported with cardiovascular involvement [52-55], namely myocarditis, as well as with renal dysfunction [56,57].

Viral shedding of SARS-CoV-2 among children

The detection of viral RNA by PCR does not directly indicate infectivity. Nevertheless, the detection of viral RNA and the measure of viral load are potentially useful markers for infectiousness, as well as for assessing disease severity and prognosis. Overall for COVID-19 patients, SARS-CoV-2 viral RNA has been detected in most bodily fluids including blood [58-60], saliva [58,59], nasopharyngeal specimens [61], urine [62], and in stool [63,64]. Based on the limited case data, shedding of viral RNA through the upper respiratory tract may be of shorter duration in children than adults. In contrast, children show prolonged viral shedding via the gastrointestinal route after clearing the virus from the respiratory tract [65]. Further, a recent study suggests that the viral load in children under five years with mild to moderate COVID-19 symptoms is higher than in older children and adults [66].

There does not appear to be a significant difference in viral RNA load between symptomatic children and symptomatic adults, indicating that children shed viral RNA (whether viable or not) in a similar manner to adults [67]. This does not, however, indicate whether children transmit the infection to an equal extent, given that the exact load of viable virus is unknown and that it will depend on the specimen from which the virus is identified (e.g. upper respiratory tract versus gastrointestinal). Children have been shown to develop neutralising antibodies after SARS-CoV-2 infection [68].

Infectiousness of children in household settings

In a manuscript (as yet not peer reviewed) relating to contact tracing efforts carried out during school closures in Trento, Italy, the attack rate among contacts of 0–14 year old cases was 22.4%, which is higher than that of working-age adults (approximately 13.1%) [69]. In this study, not all asymptomatic contacts were tested. South Korea has permissive testing recommendations for contacts identified during contact tracing, meaning that more secondary cases are identified among children than in other settings. The attack rate among household contacts of index cases aged 0–9 years and 10–19 years was 5.3% and 18.6%, respectively, indicating transmission potential in both children and adolescents, and possibly more effective transmission in adolescents than in adults [70]. These results, consistent with unpublished data from EU/EEA and UK contact tracing efforts, support the transmission potential of children, in household settings.

Seroprevalence of COVID-19 antibodies among children

Seroprevalence studies aim to determine the proportion of population groups that have detectable antibodies against SARS-CoV-2, in order to provide an indication of how many people have been infected with the virus. A number of seroprevalence studies have been undertaken in the EU/EEA region, while others are still ongoing. Table 1 summarises preliminary results found in literature searches or on countries' official websites. All studies were conducted after the peak of the first wave at various points in time, depending on national response measures (before, during or after lockdown).

Table 1. Descriptions and results of sero-epidemiological studies including children in EU/EEA Member States and Switzerland from public sources, as of 24 July 2020

Country	Number (n)	Type of study	Age group	Time of sampling (in 2020)	Timing	Laboratory method	Proportion of positive samples (%)
Seroprevalence studies designed for children and adolescent populations							
France (Paris area)* [71]	605 children	Prospective cross sectional multi-centre ambulatory paediatric clinics	0-15 years	14 April-12 May	After peak of first wave - during lockdown	Biosynex COVID-19 BSS test IgG/IgM	10.7
Germany (Baden-Württemberg)* [72]	2 466 children	Cross sectional private diagnostic labs – 2 collections	0-20 years	30 March - end April	During lockdown	Euroimmun IgG	5
France (Oise)* [73]	242 students	Retrospective closed cohort in high school	14-17 years	30 March-4 April	After school outbreak - during lockdown	Multiple assays	10.2
Germany (Saxony)* [74]	1 538 students	Cross sectional in 13 Schools of the region	14-17 years	25 May-30 June	After peak of first wave - after lockdown	Diasorin LIAISON, CMIA and Abbott	0.7
General population seroprevalence studies							
Spain [75]	6 527 children	Nationwide population based household random sampling – 2 collections	Household Focus: 0-19 years	27 April – 11 May	After peak of first wave – during lockdown	POC (Orient Gene Biotech COVID-19 IgG/IgM) & Immunoassay (Abbott Laboratories)	3.4- 3.8
Spain (Barcelona) [76]	Overall sampling 311 individuals	Random age stratified population (asymptomatic children)	0-14 and 15-29 years	21 April - 24 April	After peak of first wave - During lockdown	Rapid lateral flow immunoassay IgG/IgM	0 and 10
Switzerland (Geneva) [77]	214 children	Repeated population based household sampling	5-19 years	Three weekly samplings in April	After peak of first wave	Euroimmun IgG	6.1
Belgium [78]	N/A	National prospective cross sectional residual sera from private diagnostic labs – 2 collections	0-20 years	30 March – end April	During lockdown	Euroimmun IgG	5
Germany (Gangelt) [79]	405 households	Random sample household study	5 years-14 years and 15-34 years	30 March – 7 April	After peak of first wave - before lockdown	Euroimmun IgG	9.1 and 15.4

Country	Number (n)	Type of study	Age group	Time of sampling (in 2020)	Timing	Laboratory method	Proportion of positive samples (%)
Germany (Neustadt-am-Rennsteig) [80]	58 children	Population-based cohort – household sampling	Children-adolescents	12-22 May	After peak of first wave -after lockdown	Combination of ELISA and CLIA/CMIA tests	1.7
Netherlands [81]	Overall sampling 2 096 individuals	Nationwide random population sample	0-19 years	31 March - 13 April	During lockdown	NA	1–2%
Sweden (multiple regions) [7]	1 600 children	Residual sera from outpatients presenting for non-COVID related consultation	0-19 years	weeks 18-21	No lockdown	Bead-based multiplex serology assay	4.7–7.5

Two studies, conducted by France and Germany [71-74] had a special focus on children (0–10 years) and two on adolescents (14–17 years) in school settings. Both studies in France found a prevalence of SARS-CoV-2 antibodies of around 10%, whereas in Germany the results were <1% among the younger population.

A number of SARS-CoV-2 seroprevalence studies have been conducted in the general population. The methodology used in these studies was mainly a random household sampling, while others used convenience samples (e.g. leftover sera). When extrapolating seroprevalence results for the young age group (0–18 years), the actual denominators for this population were not always shown in detail, or included very small sample sizes. This is a limitation for the current synthesis and interpretation.

As described above, the seroprevalence results in the general population within the EU/EEA region vary from 0–10%. Although the sampling time-frames differ among the countries performing the studies (in relation to local lockdowns), the extent of mitigation measures deployed does not seem to significantly affect the level of seroprevalence in the young population. Results from Sweden, which did not close schools or enforce mandatory lockdown measures, show a presence of 4.7–7.5% of SARS-CoV-2 antibodies among the young population over a period of four weeks, which is comparable to seropositivity among adults [7].

In general, the majority of countries report slightly lower seroprevalence in children than in adult groups (20–55 years), however these differences are small and uncertain. The lower seroprevalence in children can be an indication that children are less susceptible to infection and/or less frequently infected than adults, and therefore play a less significant role in the spread of the virus [81]. A population seroprevalence study in Geneva [77] estimated that in young children aged 5–9 years the risk of being seropositive was lower (RR 0.32 (CI 0.11–0.63)) than in those aged 20–49 years.

A study from Paris, including a relatively large number of children (>600), combined RT-PCR SARS-CoV-2 and serology results to assess the spread of SARS-CoV-2 infection (i.e. the study captures both people with ongoing viral infection and those with antibodies from past exposure to the virus). Less than 2% were positive for RT-PCR for SARS-CoV-2, while seropositivity was much higher (10.7%). No significant difference was seen in the proportion of positive RT-PCR or serology results between asymptomatic and pauci-symptomatic children. However, asymptomatic children with no history of symptoms during the preceding weeks accounted for two thirds of children with positive serology results (28/41). This supports the hypothesis that asymptomatic infections are more frequent in the young than in older age groups.

In summary, cross-sectional epidemiological studies show a tendency towards lower proportions of antibodies among children and adolescents than in adults. The study done in Sweden did not show a difference between those under 19 years and working-age adults. More specialised studies need to be performed, with a focus on this population to better understand infection as well as antibody dynamics.

Evidence relating to the role of childcare and school settings in COVID-19 transmission

Evidence related to the role of childcare and school settings in COVID-19 transmission between children and adults relies on detection of potential cases or clusters, followed by extensive contact tracing and follow-up to determine if any close contacts develop symptoms and test positive for SARS-CoV-2 within the 14-day incubation period. In the following sections, evidence is provided from Member State reports to a country survey and from scientific literature.

Overview of outbreaks and transmission in childcare school settings: experiences from Member States

Of 31 EU/EEA and UK countries, 15¹ replied to the survey. To gather more detailed information and clarification of their replies, five countries² were invited to participate in a follow-up phone call.

Of the 15 countries responding to the survey, six countries specifically reported having identified COVID-19 outbreaks in school settings and nine countries reported not having identified any outbreaks. Of the nine countries not having observed outbreaks in educational facilities, four countries specified not having seen any cases at all and the remaining five reported that individual cases in pupils and/or adults had been identified, but with no evidence of secondary transmission. The fact that four of the countries had not seen any cases may partly be linked to their schools having been closed early in the pandemic.

The six countries reporting that clusters had been identified in educational settings all said that these were limited in number; only involving a few secondary cases. Only one country reported a cluster of more than 10 cases (13 confirmed, four students and nine staff), however this event was seen as an exception rather than the norm.

Ten countries replied that they did not have strong indications of children-to-adult transmission, whether in schools (all 10 countries) or in other settings (six of these 10 countries). One country reported knowledge of a single event in which one child transmitted the infection to both parents. The remaining four countries said that they could not give a specific reply to the question.

The above findings were expanded on through follow-up calls with five countries. Only one of the five countries described one or two events in which secondary transmission had been identified in a school setting.

Several of the countries with whom follow-up was arranged said that their schools had, at some point during the peak of their outbreaks, been closed as a mitigation measure, and recognised this in itself could be an explanation as to why school outbreaks had not occurred. However, these countries highlighted the fact that, up until their schools were closed (and if their schools re-opened before the summer break), outbreaks in schools had still not been observed or identified.

Two of the five countries further explained that there were challenges in achieving adequate capacity for contact tracing and outbreak investigation at some point during their epidemic peak and, therefore, perhaps not all outbreaks were identified and/or traced. However, even taking this into account, they did not consider that many school outbreaks would have been missed since their national surveillance systems would have been sensitive enough to have picked up any signals indicating that children and schools were substantially affected.

In summary, clusters in educational facilities were identified in several of the 15 reporting countries, however those that occurred were limited in number and size, and were rather exceptional events. Several countries specifically said that they had no indication that school settings played a significant role in the transmission of COVID-19. Secondary transmission in schools, either from child-to-child or from child-to-adult, was perceived to be rare. Countries where schools had re-opened by the time of the survey stated that they had not seen an increase in cases in these settings. Responses from the countries suggest that, so far, schools have not been a major outbreak environment for COVID-19 in the EU/EEA and UK.

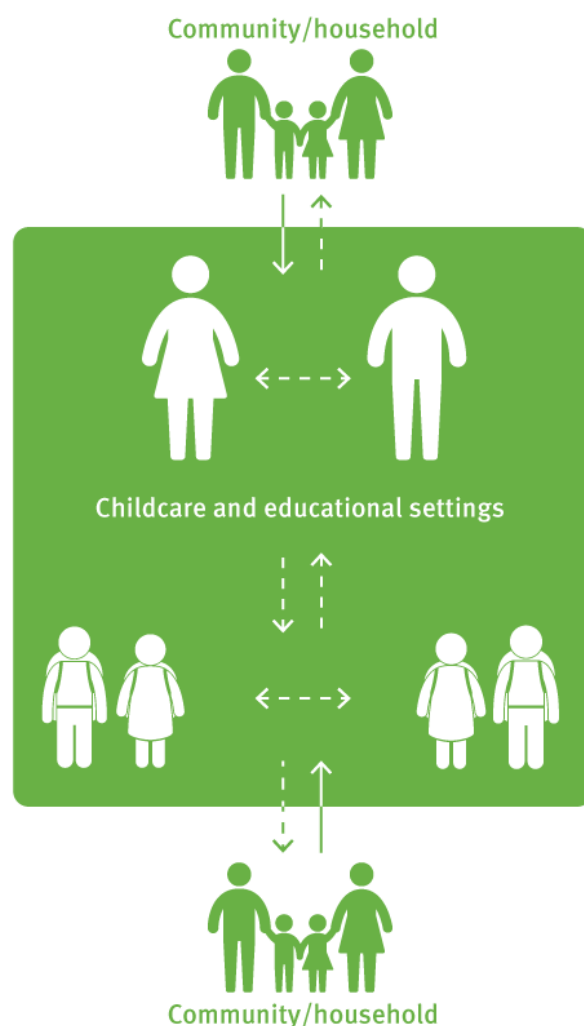
Overview of outbreaks and transmission in school settings: evidence from the literature

One overall limitation of surveillance and contact tracing studies is that surveillance is often symptom-based, thereby often omitting possible asymptomatic cases in children. To supplement surveillance and outbreak study data provided by countries, ECDC performed a literature review (see Methods) to assess the evidence for SARS-CoV-2 transmission between different actors in the school setting and the evidence for school closures on overall COVID-19 transmission (Figure 3).

¹ Cyprus, Denmark, Finland, France, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Romania, Spain, Sweden, and the United Kingdom

² Denmark, Ireland, Luxembourg, Sweden, United Kingdom

Figure 3. Diagram of known transmission routes between children and adults within childcare and educational settings and between the community/household



Note: solid arrows represent routes of transmission where there is strong evidence for transmission, dashed lines represent routes of transmission where there is variable or mixed evidence of transmission between individuals within the childcare and school settings and to the community/household outside of educational settings.

What is the evidence of transmission between children within the school setting?

Available evidence appears to suggest that transmission among children in schools is less efficient for SARS-CoV-2 than for other respiratory viruses such as influenza [82]. However, this evidence is mainly derived from school outbreaks which tend to rely on detecting symptomatic cases only and will therefore underestimate the number of infected, asymptomatic, and potentially infectious children in these outbreaks.

In France, a carefully documented study identified an infected child (age nine years) who had interactions with a large number of contacts in three different schools and did not transmit the disease, as evidenced by the large number of negative results of tested symptomatic and asymptomatic contacts [83].

In Ireland, transmission within schools was investigated prior to school closures and no evidence of secondary transmission within the school setting was found. Among the 924 child contacts and 101 adult contacts of the six cases (three children, three adults) in the school setting, there were no confirmed cases identified during the 14-day follow-up period [84]. It is important to note that this study did not consider asymptomatic infections.

In Finland, no secondary cases were identified in contact tracing and testing of 89 out of 121 contacts of a 12-year case who had attended school during their illness [85].

In Australia, a contact tracing study in 15 primary and high schools, where nine student COVID-19 cases were detected, found one secondary positive case in a primary school student (out of 735 close child contacts who were followed up) [86].

In Singapore, two preschools and one secondary school identified child index cases and tested close contacts. In a case where a preschool child was the index case (mean age 4.9 years), 34 preschool student contacts developed

potential COVID-19 symptoms during the incubation period, however all 34 symptomatic cases tested negative for SARS-CoV-2. In a case where the index child was in secondary school (mean age 12.8 years), a total of eight out of 77 students developed symptoms and were screened for SARS-CoV-2 during the incubation period. All eight symptomatic student contacts from the school tested negative [87,88].

In Israel, a first large school outbreak emerged ten days after re-opening all schools with requirement for daily health reports, hygiene, face masks, social distancing and minimal interaction between classes. The first two cases were registered on 26 May and 27 May, having no epidemiological link. Testing of the complete school community revealed 153 students (attack rate: 13.2%) and 25 staff members (attack rate: 16.6%) who were COVID-19 positive. Overall, some 260 persons were infected (students, staff members, relatives and friends) [88].

In summary, in children where COVID-19 was detected and contacts followed-up, only one child contact in the school setting was detected as SARS-CoV-2 positive during the follow-up period. The conclusion from these investigations is that child-to-child transmission in schools is uncommon and not the primary cause of SARS-CoV-2 infection of children whose infection onset coincides with the period during which they are attending school.

What is the evidence of transmission from children (students) to adults (teacher/staff) within the school setting?

In an Irish study, 101 adult contacts in the school setting of three SARS-CoV-2 positive children resulted in no additional cases [84]. It is important to note that this study did not consider asymptomatic infections.

In Australia, a contact tracing study in 15 primary and high schools where nine student COVID-19 cases were detected found no evidence of any transmission to 128 adult close contacts in the school setting [86].

In the Netherlands, as of June 2020, there had been no reports of possible COVID-19 clusters linked to schools or reports of employees infected by children [81].

In summary, where COVID-19 in children was detected and contacts followed-up, no adult contacts in the school setting have been detected as SARS-CoV-2 positive during the follow-up period. The conclusion from these investigations is that children are not the primary drivers of SARS-CoV-2 transmission to adults in the school setting.

What is the evidence of transmission from adults (teacher/staff) to children (students) within the school setting?

There is very little documented evidence of potential transmission from adults to children within the school setting. In Ireland, three adult cases had a total of 102 child contacts that did not result in detection of any secondary child cases although, only symptomatic individuals were referred for follow-up testing [84]. The outbreak in a high school in Israel did not specify the age of the index cases, making identification of adult-to-student transmission within the school setting impossible without further information [88].

In Australia, a contact tracing study in 15 primary and high schools where nine staff-member-COVID-19 cases were detected found one secondary positive case in a secondary school student (among 735 child close contacts who were followed up) [86].

In Finland, following exposure to an infected teacher, seven out of 42 exposed students developed antibodies or were PCR positive, however household or community transmission may have been the source in some of these [85].

There is ample evidence that if a child is infected by an adult, it is likely to be in the household setting. In an Italian cohort, contact with an infected person outside of the family was rarely reported and 67% of children had at least one parent who tested positive for SARS-CoV-2 infection [4,5]. It is also important to note that interactions between children and adults are different in the school setting to those in the household setting.

In summary, while there is evidence of transmission from adults to children in household settings, there is little evidence of this occurring within the school setting.

What is the evidence of transmission between adults (teacher/staff) within the school setting?

There is limited evidence within the peer-reviewed literature documenting transmission between adults within the school setting. In Sweden, where schools for children younger than 16 years remained open, the Public Health Authority analysed occupational groups within the school and found that teachers were at no higher risk of COVID-19 than the general public. Relative risks were: preschool teachers (0.7), compulsory school teachers (1.1), senior high school teachers (0.7), recreation staff (0.8), student assistants (1.1), other educators (1.0), and childcare providers (1.0) [9]. Recommendations for Swedish schools were that everyone with mild symptoms remain at home, to practise physical distancing, to cancel mass gatherings within the school setting, and to practise hand hygiene while in the school setting. See Box 1 for more information on the Swedish approach.

A study documenting an apparent school outbreak of 50 people in Chile describes an index case, a teacher, participating in multiple parent conferences about five days prior to the peak of the outbreak [89]. However, the

designation of the index case is based on testing as a result of symptoms and might therefore have missed asymptomatic children. Serology results 8–10 weeks after the outbreak suggest comparable levels of infections among children and adults at the school, but these infections might have occurred outside of the school setting, as the school in question was closed down rapidly after the index case was detected.

The conclusion from these investigations is that adults are not at higher risk of SARS-CoV-2 within the school setting than the risk in the community or household.

What is the effect of school openings on transmission to the community/household?

While there is a growing body of evidence to suggest that transmission between children and between children and adults within schools has been relatively uncommon, there have been very few studies that have assessed the impact of school closure or opening on transmission outside the school. Among those that have been published, the following have suggested that schools closure or opening could impact on community incidence:

A recently published study on the association between school closures and community incidence in the USA [90] has suggested that school closures could have been associated with up to 128.7 fewer cases per 100 000 population over 26 days and with up to 1.5 fewer deaths per 100 000 population over 16 days in areas with low starting incidence. However, these closures occurred at the time of the introduction of many other non-pharmaceutical interventions, and the authors note that it was “impossible to fully isolate potential effects of school closure”, and that “some non-pharmaceutical interventions, such as increased handwashing, could not be included due to lack of available data.” The authors also note that “The degree to which the associations with school closure relate to decreased spread of SARS-CoV-2 by children or a combination of child and adult factors is unclear.”

In Israel, a first large school outbreak emerged ten days after re-opening all schools with requirement for daily health reports, hygiene, face masks, social distancing and minimal interaction between classes [88]. The author’s report that 87 additional confirmed COVID-19 cases occurred among close contacts of the first school’s cases, including siblings attending other schools, friends and participants in sports and dancing afternoon classes, students’ parents and family members of school staff. However, the authors do not comment on the likely sequence of infection in these cases, and also note that distancing among students and between students and teachers within the school was not possible. Moreover, as a consequence of a heatwave that occurred at the time of re-opening, there was an exemption from the use of facemasks, and air-conditioning functioned continuously in all classes.

Much of the other evidence that exists on the impact, or the lack thereof, of school opening and closures on community transmission derives from observational studies and a survey undertaken by ECDC of contact points in national public health institutes in EU Member States.

Denmark reopened childcare and primary education on 15 April, with moderately high overall notification rates at national level, and did not report any increase in the reproductive number, or detect important school outbreaks. Denmark recommended splitting classes into smaller groups, keeping two metres between children, hand hygiene, and teaching more classes outside. Similarly, the Netherlands did not see a sudden increase in their reproductive number or detect significant outbreaks, when primary schools and childcare facilities opened on 11 May, with moderately high notification rates at national level. Children up to and including 12 years did not have to keep 1.5 metres apart from each other or from adults, and this measure was applied in childcare and primary education settings. Children aged 13 to 18 years did not have to physically distance from one another. Physical distancing was recommended for all adults - staying 1.5 metres apart from others as often as possible [81].

Since the beginning of the pandemic, 41% of Ireland’s 576 cases in children were linked to outbreaks in private family homes, followed by outbreaks in workplaces (n=25; 18.1%), travel related outbreaks (n=19; 13.7%), outbreaks in residential institutions (n=12; 8.7%), extended family (n=11; 8.0%) and in the community (n=8; 5.8%). None of the COVID-19 cases have been linked to outbreaks in school or childcare facilities [personal communication Ireland].

Iceland also kept both childcare institutions and primary schools open throughout the spring term and the rates of SARS-CoV-2 in children <15 years remained low compared to rates in the older age groups. Physical distancing rules did not apply to childcare institutions and primary school children and they were not limited in their leisure, sports, or music activities. Access to hand-washing facilities and disinfection was mandatory and adults had to respect the two-metre distancing rules and not gather in groups over 200 [91]. Similarly, in Sweden, the 14-day incidence for children <15 years has remained lower than all of the other age groups, even when Sweden expanded their testing policy to include mild cases (see Box 1 for further details) [6].

In summary, there is limited evidence that schools are driving transmission of COVID-19 within the community, however there are indications that community transmission is imported into or reflected in the school setting. Given that all countries have implemented additional non-pharmaceutical interventions in addition to school closures, it is difficult to assess the true impact of school closure/opening on transmission of SARS-CoV-2 within the community from the school setting itself. The report from Israel underscores the importance of the rigorous implementation of physical distancing in order to reduce exposure in school settings where COVID-19 is circulating in the community.

Box 1 – Sweden

Keeping preschools and primary schools open

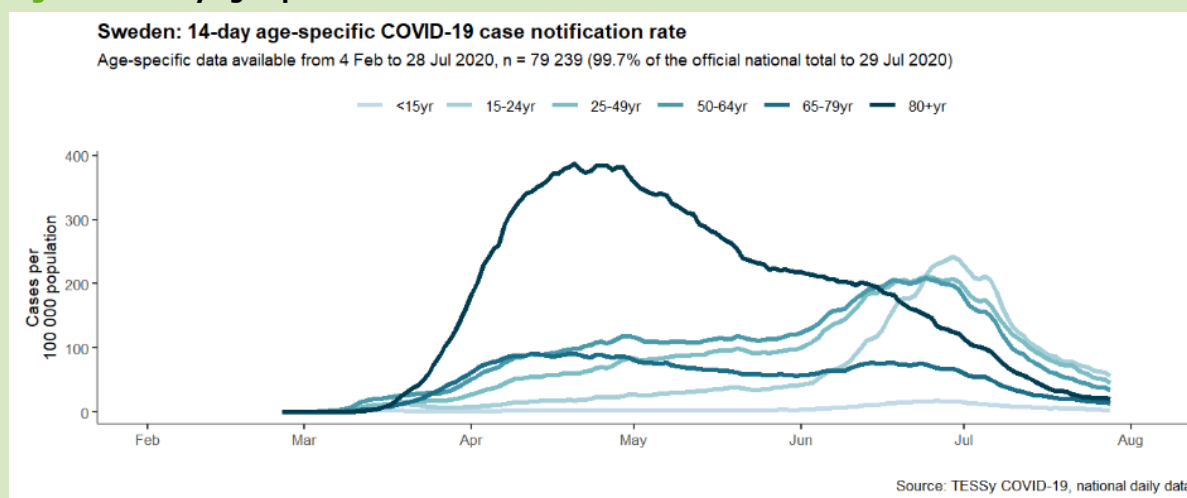
Throughout the pandemic, Sweden's decision to keep preschools and primary schools open for children under 16 years gained worldwide attention when most other countries decided to close educational establishments for all in-person schooling. The country reports that the overall incidence is continuing to decrease, with an incidence of 22 per 100 000 inhabitants for week 29, and that regional differences in incidence and severity of cases continue to exist [1].

In contrast to other EU/EEA Member States, Sweden actively kept preschool and primary schools (0–15 years of age) open during the school spring term with the condition that other measures - such as physical distancing, hand hygiene, and staying home with mild symptoms - were introduced to reduce the risk of infection. Authorities explained that the decision was based on an assessment of the epidemiological situation, available evidence on the role of children and school settings in community transmission, and the need to consider the additional health impacts of school closures on children [2]. High schools (for those aged 16–19 years) were closed and distance learning was provided as it was considered that older age groups were more independent and could manage distance learning. Furthermore, high schools commonly cover a wider geographical area, and therefore it was considered that there was a higher perceived risk involved in transportation to and from school.

In a recent report, Sweden described children being affected to a lesser extent than other age groups; as of 28 May 2020, 0–9 year olds represented 0.5% of all cases and the age group 10–19 years represented 1.2% of all cases (total number of cases as of 28 May was 35 719). Furthermore, their data show that children represent a minor proportion of all intensive care COVID-19 cases; individual cases in the 0–9 year age group and 0.3% of all ICU cases in the age group 10–19 years) [2].

Sweden's weekly epidemiological report published on 24 July 2020 [1] and in ECDC's weekly country overview [6] shows an increase in positive cases in the 0-19 age group in weeks 22–26 as testing capacity expanded to include mild cases (Figure A). Repeated serosurveys analysing residual sera from non-COVID-19 primary care patient samples in nine counties of Sweden during weeks 18–21 do not show a significant difference in seropositivity rates among 0-19 year old children and working-age adults [7].

Figure A. 14-day age-specific COVID-19 case notification rate



On 29 May 2020, Swedish authorities updated their recommendations on schools and COVID-19, presenting and taking into consideration the latest epidemiological situation, updated a review of the scientific evidence on COVID-19, children and educational settings, and a review of scientific evidence on the impact of school closures on children's health [2]. The following considerations were summarised [2]:

- Children and young people represent a small proportion of the overall number of COVID-19 cases in the country;
- Most children are infected by adults and children often have mild symptoms, if any;
- Children are considered to transmit the disease to a lesser extent than adults;
- Schools have not been seen as a significant driver of (community) transmission;
- Teachers and staff were not identified as being at increased risk of contracting COVID-19 disease compared to other occupations [9];
- The closure of schools has other negative effects on children and young people.

As of 15 June 2020, Sweden recommends that all educational facilities remain open, and that these settings must continue to implement and abide by the national recommendations for preventing and decreasing the transmission of COVID-19 [2].

Discussion

When infected and symptomatic, children appear to be able to shed the virus in similar quantities to adults, and children in households have transmitted SARS-CoV-2 to their contacts in similar proportions to adults. Less is known about the infectiousness of asymptomatic or pre-symptomatic children. The results from cross-sectional serology [86,87] and school outbreak studies, together with the low number of symptomatic and laboratory-confirmed children reported through surveillance and outbreak studies, are consistent with the majority of SARS-CoV-2 infected children being asymptomatic.

Serological studies indicate that similar, often smaller, proportions of children and adolescents than working-age adults are seropositive. However, interpretation of age-group differences in seropositivity rates is hampered by the small number of children included in many studies. Meaningful comparisons between seropositivity reported in different locations is difficult due to differences in the characteristics of the laboratory methodology used and timing of the studies in relation to the outbreak and response measures. Overall, however, there is compelling evidence that a far greater proportion of children with COVID-19 are asymptomatic than is seen among adults. Therefore, for children to have a significant potential for onward transmission, one needs to assume important asymptomatic or pre-symptomatic transmission.

The evidence available strongly suggests that transmission resulting in symptomatic infection of either children or adults is uncommon in schools. Interpretation of this evidence, and particularly extrapolation to the conclusion that transmission results in any form of infection (i.e. including asymptomatic or pauci-symptomatic infection), is hampered by the observation that asymptomatic infection is much more common in children than in adults. As such, case finding and surveillance that is based on the testing of symptomatic individuals may miss many childhood infections.

The observation that adult staff working in schools appear not to have higher rates of COVID-19 infection than other occupational groups, the relative lack of evidence of child-to-adult transmission in schools where child cases have been identified, and the evidence (albeit limited) that the re-opening of schools in EU countries has not been associated with significant increase in community transmission supports the conclusion that transmission within schools is not a major driver of COVID-19 incidence, if appropriate mitigation measures are applied within the schools and community. There is some countervailing evidence from Israel that re-opening schools might have an impact on overall rates of community transmission, but as the re-opening of schools coincided with the relaxation of other measures, the role of schools in the upsurge of COVID-19 is unclear.

In addition, an analysis of the probable origin for transmission of COVID-19 infection in outbreaks that have involved children in Ireland indicated that the most common setting was the home, followed by workplaces, travel and residential institutions, with none of the childhood cases linked to outbreaks in schools.

European public health authorities responding to our survey on school outbreaks reported very few clusters or outbreaks in schools, however the majority of countries experienced peak transmission waves during school closures, so exposure opportunities have been limited. From the literature, there are limited case reports of outbreaks in schools, which perhaps reflect the fact that such outbreaks have occurred relatively infrequently to date. Available study results are also somewhat inconsistent; contact tracing of the index cases behind outbreaks in Australia [86], France [83], and Ireland [84] identified very few positive cases among exposed individuals, while a recent report from Israel [88] suggests that up to 32% of cohort contacts in a high school setting were virus positive although, as noted above, these results should be interpreted with caution.

Overall, there is limited evidence from EU/EEA countries and the literature to indicate that schools are driving transmission within the community. However, there are indications that community transmission is imported into or reflected in the school setting. Given that all countries have implemented non-pharmaceutical interventions in addition to school closures, and that they have sometimes relaxed these when re-opening schools, it is difficult to assess the true impact of school closure and opening on transmission of SARS-CoV-2 within the community from the school setting itself. Since schools are an integral part of the communities they serve, results from outbreak studies in schools are difficult to disentangle from concurrent community outbreaks. However, the report from Israel underscores the importance of the rigorous implementation of physical distancing and exposure reduction in school settings where COVID-19 is circulating in the community.

As highlighted in the Swedish context and by a review of work carried out among vulnerable groups in the EU/EEA, there may be reasons beyond COVID-19 prevention, which may be of importance to policy makers when considering whether to close or open schools. These include physical and mental health concerns, educational attainment, and the ability of caregivers to fulfil employment obligations.

Based on available evidence, it is important that non-pharmaceutical measures in the community, such as physical distancing, cancellation of mass gatherings, hand hygiene and staying home if symptomatic, remain integral to preventing schools from becoming a setting for accelerating onward transmission. If these measures are in place in the community, and if infection control policies - including practising hand hygiene and staying at home for students and staff with symptoms - are also applied in schools themselves, the likelihood of COVID-19 transmission in the school setting is not higher than the likelihood in the community at-large.

Limitations

This technical report is based on information and data available to ECDC at the time of publication.

- There is still limited epidemiological and clinical information on COVID-19 in children (e.g. efficiency of different modes of transmission, proportion of mild and asymptomatic cases, transmission during incubation and recovery period, effectiveness of treatment regimes, risk factors for severe illness other than age and effective preventive measures).
- Most case-based surveillance systems in the EU/EEA countries do not collect information that would allow public health authorities to identify outbreaks or clusters in specific schools without notification from the school itself.
- The majority of seroprevalence results among children and adolescent population presented in this report were extracted from general population-based studies, with a variety of sampling methodology used. Very often, denominators were not mentioned for this population, or involved very small numbers, making comparison and interpretation of results difficult.
- Results from serological studies are often not adjusted for test characteristics.
- Information on testing strategies in educational settings was not available.
- Many countries are not testing asymptomatic cases, so it is difficult to detect and understand transmission among mild or asymptomatic children and teachers.
- It is difficult to identify all potential routes of transmission within school settings as some activities have been limited (e.g. school sporting events, mixed mass gatherings of students and adults such as school concerts, performances, and graduations, etc.). The potential impact of allowing such events to take place within the school setting is still unknown.
- Interpretation of outcomes of school outbreak reports in the midst of ongoing community transmission is difficult.
- This report focuses on evidence for COVID-19, which remains limited. Not enough is known as yet to assess whether extrapolation of the evidence related to seasonal influenza transmission in schools and the impact of school closures would provide a valid basis for policy decisions. As such, this evidence has not been reviewed in the current document.

Research needs

The role of children in COVID-19 transmission is yet to be fully elucidated and there is a need to determine the extent to which children are a) susceptible to SARS-CoV-2 virus across different age groups, and b) capable of transmitting infection to others when asymptomatic or symptomatic.

In terms of susceptibility, ongoing large-scale surveillance and seroprevalence studies will further inform the proportion of children infected compared to adults. Hence, it is important that children are represented in the sampling for these studies. Interpretation of surveillance would also benefit from improved understanding of the underlying immune response and antibody dynamics in children, including the ability of children to elicit a detectable immune response following both asymptomatic and symptomatic infection.

It is known that children are able to transmit infection to others, but the transmission dynamics and primary routes of transmission remain unclear. Evidence suggests that asymptomatic infection may be more prevalent in children than in adults, but further confirmatory research is needed, together with work to understand both the underlying biological mechanisms of this differential response to infection, and how that impacts the COVID-19 epidemiology. Improved understanding of pre-symptomatic and asymptomatic infection will determine the extent to which children play a role in onward transmission of SARS-CoV-2 to their peers and to adults in both school and community settings.

Specifically, in school settings, risk mitigation may benefit from operational research to understand and optimise approaches; this includes assessment of efficacy and compliance of IPC measures in school settings across age groups, such as physical distancing measures, mask wearing, etc. There would also be benefit in conducting formal assessments on the relative efficiency of high-level school-specific measures, such as restrictions in class sizes and access. Modelling work will probably provide valuable information on these issues in addition to broader societal impacts from COVID-based adjustment to school attendance, such as social mixing among children and changes to social interactions as a whole. At EU level, it may be beneficial to review specific measures used and to share best practices to inform approaches in the Member States.

Conclusions

As countries perform their own risk assessments on whether schools should re-open after the summer break, this technical report provides a) the epidemiological situation and disease characteristics relating to COVID-19 among children (0–18 years) in EU/EEA countries and the United Kingdom (UK), and b) evidence of the role of childcare and school (preschool, primary and secondary schools) settings in COVID-19 transmission and of the secondary transmission of COVID-19 within childcare and other educational settings.

School outbreaks are not a prominent feature in the COVID-19 pandemic, which may at least partially be due to the fact that the majority of children do not develop symptoms when infected with SARS-CoV-2. Investigations of cases identified in school settings suggest that child-to-child transmission in schools is uncommon and not the primary cause of SARS-CoV-2 infection in children whose onset of infection coincides with the period during which they are attending school, in particular in preschools and primary schools. The only EU/EEA countries (Sweden and Iceland) that kept preschools or primary schools open with mitigation measures (e.g. hand hygiene, physical distancing, staying home when ill, etc.) during their epidemic did not report larger numbers of hospitalised cases among children, despite the overall outbreak being severe and prolonged in Sweden. EU/EEA countries that partially opened their schools before the summer break, often with community mitigation measures, have not experienced school outbreaks or major resurgences - in contrast to Israel, which experienced a significant second wave in July 2020 and has reported school outbreaks.

Closures of childcare and educational institutions are unlikely to be an effective single control measure for community transmission of COVID-19 and such closures would be unlikely to provide significant additional protection for the health of children, most of whom develop a very mild form of COVID-19 disease, if any. Therefore, any decisions on school closures should be made for the purpose of mitigating the impact of community epidemics and will need to be taken in the context of all other community mitigation measures. ECDC has commissioned a systematic literature review to look at the evidence on the role of school closures in community transmission to complement the current report. Special consideration needs to be given to educational institutions serving children with severe pre-existing medical vulnerabilities and approaches to students and staff with severe medical vulnerabilities.

Targeted measures in schools to increase physical distancing, improve ventilation and cleaning, hand-washing facilities and provision of personal protection, will probably mitigate the possible transmission of COVID-19 in schools and will be helpful in mitigating the impact of other respiratory infections during the approaching autumn and winter season, thereby reducing pressure on schools and healthcare.

Reactive school closures following community outbreaks, and cases or outbreaks in schools are unlikely to be timely enough to have a significant impact on the dynamics of the local epidemic, but may need to be made due to absenteeism, or staff and parental concerns. Preparedness plans for such closures, developed collaboratively by schools and public health authorities, will help rational decision-making and the communication of such decisions. ECDC guidance on contact management and testing in schools provides targeted testing recommendations for contact tracing (publication pending).

In conclusion, this review of evidence has shown that children do become infected and, when symptomatic, shed virus in similar quantities to adults and can transmit the disease as effectively as adults in households. The infectiousness of asymptomatic children is unknown. While very few significant outbreaks of COVID-19 have been documented they do occur, and may be difficult to detect due to the relative lack of symptoms in children. However, what evidence does exist suggests that transmission within schools has been uncommon, and therefore, if appropriate physical distancing, hygiene, and other measures are applied, schools are unlikely to be more effective propagating environments than occupational or leisure facilities with similar densities of people. Consequently, decisions on measures in schools and school closures/openings should be made consistently, in conjunction with decisions on other physical distancing measures.

Contributing experts

ECDC experts (in alphabetical order): Cornelia Adlhoj, Barbara Albiger, Agoritsa Baka, Orlando Cenciarelli, Scott Chiossi, Helena de Carvalho Gomes, Erika Duffell, Lisa Ferland, Lea Franconeri, Tjede Funk, Joana Gomes Dias, Maria Keramarou, Tommi Kärki, Csaba Ködmön, Katrin Leitmeyer, Howard Needham, Lina Nerlander, Sabrina Nothdurfter, Aurea Oradini Alacreu, Anastasia Pharris, Pasi Penttinen, Andreea Salajan, Gianfranco Spiteri, Bertrand Sudre, Emma Wiltshire, Andrea Würz.

External experts: Ana Paula Coutinho Rehse (WHO Regional Office for Europe)

All external experts have submitted declarations of interest, and a review of these did not reveal any conflicts of interest.

Acknowledgements

ECDC gratefully acknowledges National Focal Points in Cyprus, Denmark, Finland, France, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Romania, Spain, Sweden, and the United Kingdom, who responded to the country-based data collection survey. ECDC also thanks colleagues from the European Agency for Safety and Health at Work (EU-OSHA) for reviewing the document.

References

1. Folkhälsomyndigheten. Veckorapport om covid-19, vecka 29 [Internet]. Stockholm: Folkhälsomyndigheten; 2020. Available from: https://www.folkhalsomyndigheten.se/globalassets/statistik-uppfoljning/smittsamma-sjukdomar/veckorapporter-covid-19/2020/covid-19-veckorapport-vecka-29-final_updated.pdf.
2. Folkhälsomyndigheten. Covid-19 hos barn och unga - en kunskapssammanställning [Internet]. Stockholm: Folkhälsomyndigheten; 2020. Available from: <https://www.folkhalsomyndigheten.se/contentassets/03fff9a4b6ba4b36b84f69a5f9486cbf/covid-19-barn-unga-kunskapssammanstallning.pdf>.
3. European Commission/EACEA/Eurydice. The Structure of the European Education Systems 2018/19: Schematic Diagrams [Internet]. Luxembourg: Publications Office of the European Union; 2018. Available from: https://eacea.ec.europa.eu/national-policies/eurydice/sites/eurydice/files/the_structure_of_the_european_education_systems_2018_19.pdf.
4. Parri N, Lenge M, Buonsenso D. Children with Covid-19 in Pediatric Emergency Departments in Italy. The New England Journal of Medicine. 2020;383(2):187-90.
5. Garazzino S, Montagnani C, Donà D, Meini A, Felici E, Vergine G, et al. Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020. Euro Surveillance: bulletin European sur les maladies transmissibles = European communicable disease bulletin. 2020 May;25(18).
6. European Centre for Disease Prevention and Control (ECDC). COVID-19 country overviews - Sweden [Internet]. ECDC; 2020 [cited 27 July 2020]. Available from: https://covid19-country-overviews.ecdc.europa.eu/#33_sweden.
7. Folkhälsomyndigheten. Påvisning av antikroppar efter genomgången covid-19 i blodprov från öppenvården (Delrapport 1) [Internet]. Stockholm: Folkhälsomyndigheten; 2020. Available from: <https://www.folkhalsomyndigheten.se/contentassets/9c5893f84bd049e691562b9eeb0ca280/pavisning-antikroppar-genomgangen-covid-19-blodprov-oppenvarden-delrapport-1.pdf>.
8. Melnick H, Darling-Hammond L, Leung M, Yun C, Schachner A, Plasencia S, et al. Reopening schools in the context of COVID-19: Health and safety guidelines from other countries. Learning Policy Institute. 2020.
9. Folkhälsomyndigheten. Förekomst av covid-19 i olika yrkesgrupper [Internet]. Stockholm: Folkhälsomyndigheten; 2020. Available from: <https://www.folkhalsomyndigheten.se/publicerat-material/publikationsarkiv/f/forekomst-av-covid-19-i-olika-yrkesgrupper/>.
10. European Agency for Safety and Health at Work (EU-OSHA). OSH management: legal duties and compliance - Obligations of the employer [Internet]. EU-OSHA; 2020 [cited 29 July 2020]. Available from: https://oshwiki.eu/wiki/OSH_management:_legal_duties_and_compliance#Obligations_of_the_employer.
11. European Agency for Safety and Health at Work (EU-OSHA). COVID-19: Back to the workplace - Adapting workplaces and protecting workers [Internet]. EU-OSHA; 2020 [cited 24 July 2020]. Available from: https://oshwiki.eu/wiki/COVID-19:_Back_to_the_workplace_-_Adapting_workplaces_and_protecting_workers.
12. World Health Organization (WHO). Considerations for school-related health measures in the context of COVID-19 [Internet]. Geneva: WHO; 2020 [updated 10 May 2020]. Available from: <https://www.who.int/publications/i/item/considerations-for-school-related-public-health-measures-in-the-context-of-covid-19>.
13. European Network of Ombudspersons for Children (ENOC) and United Nations International Children's Fund (UNICEF). Ombudspersons and Commissioners for Children's Challenges and Responses to Covid-19 [Internet]. 2020 [22 July 2020]. Available from: <http://enoc.eu/wp-content/uploads/2020/06/ENOC-UNICEF-COVID-19-survey-updated-synthesis-report-FV.pdf>.
14. United Nations Educational, Scientific and Cultural Organization (UNESCO). Adverse consequences of school closures [22 July 2020]. Available from: <https://en.unesco.org/covid19/educationresponse/consequences>.
15. Van Lancker W, Parolin Z. COVID-19, school closures, and child poverty: a social crisis in the making. The Lancet Public Health. 2020 May;5(5):e243-e4.
16. Fantini MP, Reno C, Biserni GB, Savoia E, Lanari M. COVID-19 and the re-opening of schools: a policy maker's dilemma. Italian Journal of Pediatrics. 2020;46(1):79.
17. Courtney D, Watson P, Battaglia M, Mulsant BH, Szatmari P. COVID-19 Impacts on Child and Youth Anxiety and Depression: Challenges and Opportunities. Canadian Journal of Psychiatry. 2020;706743720935646.
18. Cluver L, Lachman JM, Sherr L, Wessels I, Krug E, Rakotomalala S, et al. Parenting in a time of COVID-19. Lancet (London, England). 2020 Apr 11;395(10231):e64.
19. Norman RE, Byambaa M, De R, Butchart A, Scott J, Vos T. The long-term health consequences of child physical abuse, emotional abuse, and neglect: a systematic review and meta-analysis. PLoS Med. 2012;9(11):e1001349.
20. European Centre for Disease Prevention and Control (ECDC). COVID-19 Surveillance Report, Week 27 [Internet]. ECDC; 2020 [21 July 2020]. Available from: <http://covid19-surveillance-report.ecdc.europa.eu>.
21. Mantovani A, Rinaldi E, Zusi C, Beatrice G, Saccomani MD, Dalbeni A. Coronavirus disease 2019 (COVID-19) in children and/or adolescents: a meta-analysis. Pediatric Research. 2020:1-6.

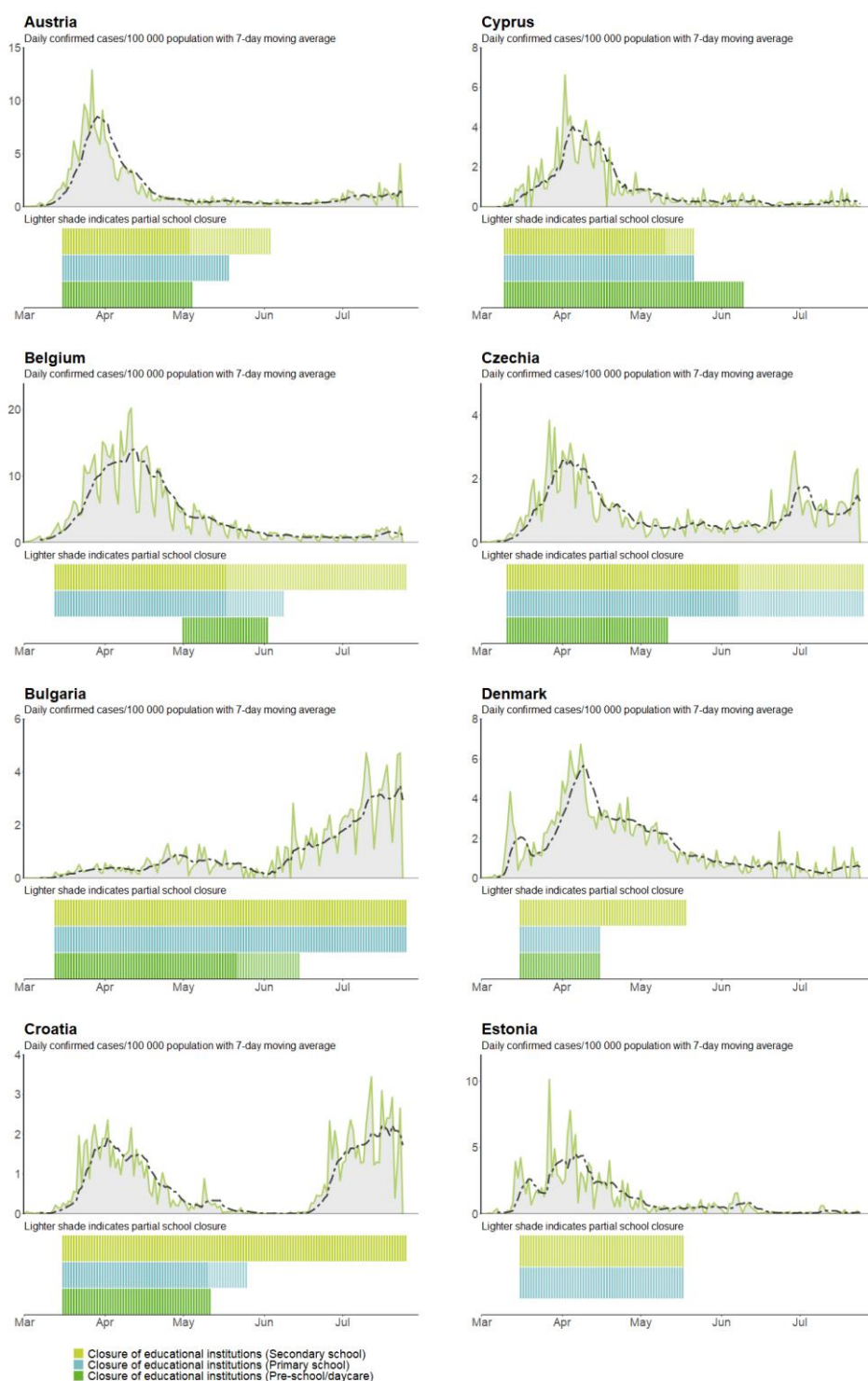
22. Patel NA. Pediatric COVID-19: Systematic review of the literature. *American Journal of Otolaryngology*. 2020;41(5):102573.
23. Castagnoli R, Votto M, Licari A, Brambilla I, Bruno R, Perlini S, et al. Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection in Children and Adolescents: A Systematic Review. *JAMA Pediatrics*. 2020.
24. Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta Paediatrica*. 2020 Jun;109(6):1088-95.
25. Raba AA, Abobaker A, Elgenaidi IS, Daoud A. Novel Coronavirus Infection (COVID-19) in Children Younger Than One Year: A Systematic Review of Symptoms, Management and Outcomes. *Acta Paediatrica*. 2020.
26. Rajapakse N, Dixit D. Human and novel coronavirus infections in children: a review. *Paediatrics and International Child Health*. 2020:1-20.
27. Götzinger F, Santiago-García B, Noguera-Julián A, Lanaspá M, Lancella L, Calò Carducci FI, et al. COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study. *The Lancet Child & Adolescent Health*. 2020.
28. Ciofi Degli Atti ML, Campana A, Muda AO, Concato C, Ravà L, Ricotta L, et al. Facing SARS-CoV-2 Pandemic at a COVID-19 Regional Children's Hospital in Italy. *The Pediatric Infectious Disease Journal*. 2020.
29. Romani L, Chiurchiù S, Santilli V, Bernardi S, Lombardi MH, Scarselli A, et al. COVID-19 in Italian pediatric patients: the experience of a tertiary children's hospital. *Acta Paediatrica*. 2020.
30. Armann JP, Diffloth N, Simon A, Doenhardt M, Hufnagel M, Trotter A, et al. Hospital Admission in Children and Adolescents With COVID-19. *Deutsches Ärzteblatt International*. 2020;117(21):373-4.
31. Kanthimathinathan HK, Dhesi A, Hartshorn S, Ali SH, Kirk J, Nagakumar P, et al. COVID-19: A UK Children's Hospital Experience. *Hospital Pediatrics*. 2020.
32. Korkmaz MF, Türe E, Dorum BA, Kılıç ZB. The Epidemiological and Clinical Characteristics of 81 Children with COVID-19 in a Pandemic Hospital in Turkey: an Observational Cohort Study. *Journal of Korean Medical Science*. 2020;35(25):e236.
33. Hildenwall H, Luthander J, Rhedin S, Hertting O, Olsson-Åkefeldt S, Melén E, et al. Paediatric COVID-19 admissions in a region with open schools during the two first months of the pandemic. *Acta Paediatrica*. 2020.
34. Rokkas T. Gastrointestinal involvement in COVID-19: a systematic review and meta-analysis. *Annals of Gastroenterology*. 2020 Jul-Aug;33(4):355-65.
35. Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, et al. Epidemiology of COVID-19 Among Children in China. *Pediatrics*. 2020 Jun;145(6).
36. Streng A, Hartmann K, Armann J, Berner R, Liese JG. [COVID-19 in hospitalized children and adolescents]. *Monatsschrift Kinderheilkunde : Organ der Deutschen Gesellschaft für Kinderheilkunde*. 2020:1-12.
37. Zhang L, Peres TG, Silva MVF, Camargos P. What we know so far about Coronavirus Disease 2019 in children: A meta-analysis of 551 laboratory-confirmed cases. *Pediatric Pulmonology*. 2020 Aug;55(8):2115-27.
38. Nghochuzie NN, Olwal CO, Udoakang AJ, Amenga-Etego LN, Amambua-Ngwa A. Pausing the Fight Against Malaria to Combat the COVID-19 Pandemic in Africa: Is the Future of Malaria Bleak? *Frontiers in Microbiology*. 2020;11:1476.
39. Devulapalli CS. COVID-19 is milder in children possibly due to cross-immunity. *Acta Paediatrica*. 2020.
40. Ng K, Faulkner N, Cornish G, Rosa A, Earl C, Wrobel A, et al. Pre-existing and de novo humoral immunity to SARS-CoV-2 in humans. *BioRxiv*. 2020.
41. EuroMOMO and Statens Serum Institut (SSI). EuroMOMO [Internet]. 2020 [cited 26 July 2020]. Available from: <https://www.euromomo.eu/>.
42. World Health Organization (WHO). Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19) [Internet]. Geneva2020 [21 July 2020]. Available from: <https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf>.
43. Meena J, Yadav J, Saini L, Yadav A, Kumar J. Clinical Features and Outcome of SARS-CoV-2 Infection in Children: A Systematic Review and Meta-analysis. *Indian Pediatrics*. 2020.
44. Yu Y, Chen P. Coronavirus Disease 2019 (COVID-19) in Neonates and Children From China: A Review. *Frontiers in Pediatrics*. 2020;8:287.
45. US Centers for Disease Control and Prevention (CDC). Emergency preparedness and response: health alert network [21 July 2020]. Available from: <https://emergency.cdc.gov/han/2020/han00432.asp>
46. Royal College of Paediatrics and Child Health. Guidance: pediatric multisystem inflammatory syndrome temporally associated with COVID-19 [21 July 2020]. Available from: <https://www.rcpch.ac.uk/resources/guidance-paediatric-multisystem-inflammatory-syndrome-temporally-associated-covid-19>.
47. World Health Organization (WHO). Multisystem inflammatory syndrome in children and adolescents with COVID-19 [Internet]. 2020 [21 July 2020]. Available from: <https://www.who.int/publications/i/item/multisystem-inflammatory-syndrome-in-children-and-adolescents-with-covid-19>.
48. Riphagen S, Gomez X, Gonzalez-Martinez C, Wilkinson N, Theocharis P. Hyperinflammatory shock in children during COVID-19 pandemic. *Lancet (London, England)*. 2020 May 23;395(10237):1607-8.
49. Rowley AH. Understanding SARS-CoV-2-related multisystem inflammatory syndrome in children. *Nature Reviews Immunology*. 2020:1-2.

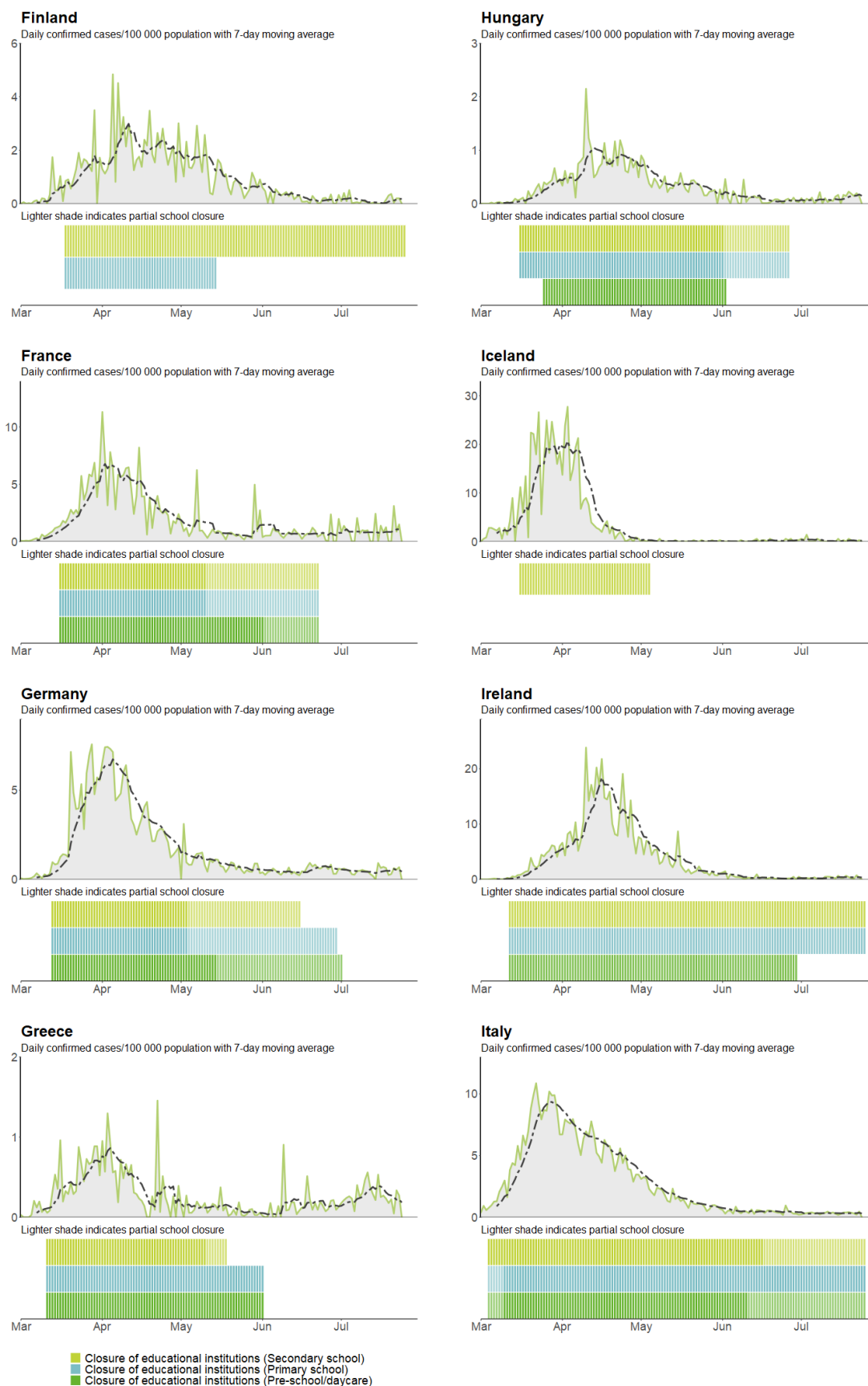
50. Simpson JM, Newburger JW. Multi-System Inflammatory Syndrome in Children in Association with COVID-19. Circulation. 2020.
51. European Centre for Disease Prevention and Control (ECDC). Paediatric inflammatory multisystem syndrome and SARS-CoV-2 infection in children [Internet]. ECDC; 2020 [21 July 2020]. Available from: <https://www.ecdc.europa.eu/en/publications-data/paediatric-inflammatory-multisystem-syndrome-and-sars-cov-2-rapid-risk-assessment>.
52. Ranabothu S, Onteddu S, Nalleballe K, Dandu V, Veerapaneni K, Veerapandiyan A. Spectrum of COVID-19 in Children. Acta Paediatrica. 2020.
53. Ciuca IM. COVID-19 in Children: An Ample Review. Risk Management and Healthcare Policy. 2020;13:661-9.
54. Del Barba P, Canarutto D, Sala E, Frontino G, Guarneri MP, Camesasca C, et al. COVID-19 cardiac involvement in a 38-day old infant. Pediatric Pulmonology. 2020 Aug;55(8):1879-81.
55. Rodríguez-González M, Rodríguez-Campoy P, Sánchez-Códez M, Gutiérrez-Rosa I, Castellano-Martínez A, Rodríguez-Benítez A. New onset severe right ventricular failure associated with COVID-19 in a young infant without previous heart disease. Cardiology in the Young. 2020:1-4.
56. Stewart DJ, Hartley JC, Johnson M, Marks SD, du Pré P, Stojanovic J. Renal dysfunction in hospitalised children with COVID-19. The Lancet Child & Adolescent Health. 2020.
57. Deep A, Bansal M, Ricci Z. Acute Kidney Injury and Special Considerations during Renal Replacement Therapy in Children with Coronavirus Disease-19: Perspective from the Critical Care Nephrology Section of the European Society of Paediatric and Neonatal Intensive Care. Blood Purification. 2020:1-11.
58. Backer JA, Klinkenberg D, Wallinga J. Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20-28 January 2020. Euro Surveillance: bulletin Européen sur les maladies transmissibles = European communicable disease bulletin. 2020 Feb;25(5).
59. Lavezzo E, Franchin E, Ciavarella C, Cuomo-Dannenburg G, Barzon L, Del Vecchio C, et al. Suppression of a SARS-CoV-2 outbreak in the Italian municipality of Vo'. Nature. 2020.
60. Chang L, Yan Y, Wang L. Coronavirus Disease 2019: Coronaviruses and Blood Safety. Transfusion Medicine Reviews. 2020 Apr;34(2):75-80.
61. Lu J, Gu J, Li K, Xu C, Su W, Lai Z, et al. COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020. Emerging Infectious Diseases. 2020 Jul;26(7):1628-31.
62. Peng L, Liu J, Xu W, Luo Q, Chen D, Lei Z, et al. SARS-CoV-2 can be detected in urine, blood, anal swabs, and oropharyngeal swabs specimens. Journal of Medical Virology. 2020.
63. Cai J, Xu J, Lin D, Yang Z, Xu L, Qu Z, et al. A case series of children with 2019 novel coronavirus infection: clinical and epidemiological features. Clinical Infectious Diseases. 2020.
64. Cheung KS, Hung IFN, Chan PPY, Lung KC, Tso E, Liu R, et al. Gastrointestinal Manifestations of SARS-CoV-2 Infection and Virus Load in Fecal Samples From a Hong Kong Cohort: Systematic Review and Meta-analysis. Gastroenterology. 2020;159(1):81-95.
65. Xu CLH, Raval M, Schnall JA, Kwong JC, Holmes NE. Duration of Respiratory and Gastrointestinal Viral Shedding in Children With SARS-CoV-2: A Systematic Review and Synthesis of Data. The Pediatric Infectious Disease Journal. 2020.
66. Heald-Sargent T, Muller WJ, Zheng X, Rippe J, Patel AB, Kociolek LK. Age-Related Differences in Nasopharyngeal Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Levels in Patients With Mild to Moderate Coronavirus Disease 2019 (COVID-19). JAMA Pediatrics. 2020.
67. Jones TC, Mühlemann B, Veith T, Biele G, Zuchowski M, Hoffmann J, et al. An analysis of SARS-CoV-2 viral load by patient age. medRxiv. 2020.
68. Sermet-Gaudelus I, Temmam S, Huon C, Behillil S, Gajdos V, Bigot T, et al. Prior infection by seasonal coronaviruses does not prevent SARS-CoV-2 infection and associated Multisystem Inflammatory Syndrome in children. medRxiv. 2020.
69. Fateh-Moghadam P, Battisti L, Molinaro S, Fontanari S, Dallago G, Binkin N, et al. Contact tracing during Phase I of the COVID-19 pandemic in the Province of Trento, Italy: key findings and recommendations. medRxiv. 2020:2020.07.16.20127357.
70. Park YJ, Choe YJ, Park O, Park SY, Kim YM, Kim J, et al. Contact Tracing during Coronavirus Disease Outbreak, South Korea, 2020. Emerging Infectious Diseases. 2020;26(10).
71. Cohen R, Jung C, Ouldali N, Sellam A, Batard C, Cahn-Sellem F, et al. Assessment of spread of SARS-CoV-2 by RT-PCR and concomitant serology in children in a region heavily affected by COVID-19 pandemic. medRxiv. 2020.
72. Debatin K-M, Henneke P, Hoffmann GF, Kräusslich H-G, Renk H. Prevalence of COVID-19 in children in Baden-Württemberg - Preliminary study report [21 July 2020]. Available from: https://www.klinikum.uni-heidelberg.de/fileadmin/pressestelle/Kinderstudie/Prevalence_of_COVID-19_in_BaWu_.pdf.
73. Fontanet A, Tondeur L, Madec Y, Grant R, Besombes C, Jolly N, et al. Cluster of COVID-19 in northern France: A retrospective closed cohort study. MedRxiv. 2020.
74. Armann JP, Unrath M, Kirsten C, Lueck C, Dalpke A, Berner R. Anti-SARS-CoV-2 IgG antibodies in adolescent students and their teachers in Saxony, Germany (SchoolCoviDD19): very low seroprevalence and transmission rates. medRxiv. 2020.

75. Pollán M, Pérez-Gómez B, Pastor-Barriuso R, Oteo J, Hernán MA, Pérez-Olmeda M, et al. Prevalence of SARS-CoV-2 in Spain (ENE-COVID): a nationwide, population-based seroepidemiological study. *Lancet* (London, England). 2020.
76. Brotons C, Serrano J, Fernandez D, Garcia-Ramos C, Ichazo B, Lemaire J, et al. Seroprevalence against COVID-19 and follow-up of suspected cases in primary health care in Spain. *medRxiv*. 2020.
77. Stringhini S, Wisniak A, Piumatti G, Azman AS, Lauer SA, Baysson H, et al. Repeated seroprevalence of anti-SARS-CoV-2 IgG antibodies in a population-based sample from Geneva, Switzerland. *medRxiv*. 2020.
78. Herzog S, De Bie J, Abrams S, Wouters I, Ekin E, Patteet L, et al. Seroprevalence of IgG antibodies against SARS coronavirus 2 in Belgium: a prospective cross-sectional study of residual samples. *medRxiv*. 2020.
79. Streeck H, Schulte B, Kuemmerer B, Richter E, Höller T, Fuhrmann C, et al. Infection fatality rate of SARS-CoV-2 infection in a German community with a super-spreading event. *medrxiv*. 2020.
80. Weis S, Scherag A, Baier M, Kiehntopf M, Kamradt T, Kolanos S, et al. Seroprevalence of SARS-CoV-2 antibodies in an entirely PCR-sampled and quarantined community after a COVID-19 outbreak-the CoNAN study. *medRxiv*. 2020.
81. Rijksinstituut voor Volksgezondheid en Milieu (RIVM). Children and COVID-19 [Internet]. 2020 [21 July 2020]. Available from: <https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19>.
82. Viner RM, Russell SJ, Croker H, Packer J, Ward J, Stansfield C, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child & Adolescent Health*. 2020 May;4(5):397-404.
83. Danis K, Epaulard O, Bénet T, Gaymard A, Campoy S, Bothelo-Nevers E, et al. Cluster of coronavirus disease 2019 (Covid-19) in the French Alps, 2020. *Clinical Infectious Diseases*. 2020.
84. Heavey L, Casey G, Kelly C, Kelly D, McDarby G. No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020. *Euro Surveillance: bulletin Européen sur les maladies transmissibles = European communicable disease bulletin*. 2020 May;25(21).
85. Dub T, Erra E, Hagberg L, Sarvikivi E, Virta C, Jarvinen A, et al. Transmission of SARS-CoV-2 following exposure in school settings: experience from two Helsinki area exposure incidents. *medRxiv*. 2020:2020.07.20.20156018.
86. Australian National Centre for Immunisation Research and Surveillance (NCIRS). COVID-19 in schools – the experience in NSW [Internet]. Sydney: NCIRS; 2020. Available from: http://ncirs.org.au/sites/default/files/2020-04/NCIRS%20NSW%20Schools%20COVID_Summary_FINAL%20public_26%20April%202020.pdf.
87. Yung CF, Kam KQ, Nadua KD, Chong CY, Tan NWH, Li J, et al. Novel coronavirus 2019 transmission risk in educational settings. *Clinical Infectious Diseases*. 2020.
88. Stein-Zamir C, Abramson N, Shoob H, Libal E, Bitan M, Cardash T, et al. A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020. *Euro Surveill*. 2020;25(29):pii=2001352.
89. Torres JP, Piñera C, De La Maza V, Lagomarcino AJ, Simian D, Torres B, et al. SARS-CoV-2 antibody prevalence in blood in a large school community subject to a Covid-19 outbreak: a cross-sectional study. *Clinical Infectious Diseases*. 2020.
90. Auger KA, Shah SS, Richardson T, Hartley D, Hall M, Warniment A, et al. Association Between Statewide School Closure and COVID-19 Incidence and Mortality in the US. *JAMA*. 2020.
91. European Centre for Disease Prevention and Control (ECDC). COVID-19 country overviews - Iceland [Internet]. ECDC; 2020 [cited 27 July 2020]. Available from: https://covid19-country-overviews.ecdc.europa.eu/#17_iceland.
92. Chu DK, Akl EA, Duda S, Solo K, Yaacoub S, Schünemann HJ. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *Lancet* (London, England). 2020;395(10242):1973-87.
93. McKie R. Did singing together spread coronavirus to four choirs? [Internet]. *The Guardian*; 2020 [cited 28 July 2020]. Available from: <https://www.theguardian.com/world/2020/may/17/did-singing-together-spread-coronavirus-to-four-choirs>.
94. Dawson T. How an Edmonton curling tournament became a hotspot for the COVID-19 outbreak in Canada [Internet]. *National Post*; 2020 [cited 28 July 2020]. Available from: <https://nationalpost.com/news/how-an-edmonton-curling-tournament-became-a-hotspot-for-the-covid-19-outbreak-in-canada>.
95. European Centre for Disease Prevention and Control (ECDC). Using face masks in the community - Reducing COVID-19 transmission from potentially asymptomatic or pre-symptomatic people through the use of face masks [Internet]. ECDC; 2020 [23 July 2020]. Available from: <https://www.ecdc.europa.eu/en/publications-data/using-face-masks-community-reducing-covid-19-transmission#:~:text=The%20use%20of%20face%20masks%20in%20public%20may%20serve%20as,symp toms%20or%20who%20remain%20asymptomatic>.
96. European Committee for Standardization. Community face coverings - Guide to minimum requirements, methods of testing and use [Internet]. Brussels 2020. Available from: https://www.cencenelec.eu/research/CWA/Documents/CWA17553_2020.pdf.
97. Knibbs LD, Morawska L, Bell SC, Grzybowski P. Room ventilation and the risk of airborne infection transmission in 3 health care settings within a large teaching hospital. *American Journal of Infection Control*. 2011 Dec;39(10):866-72.

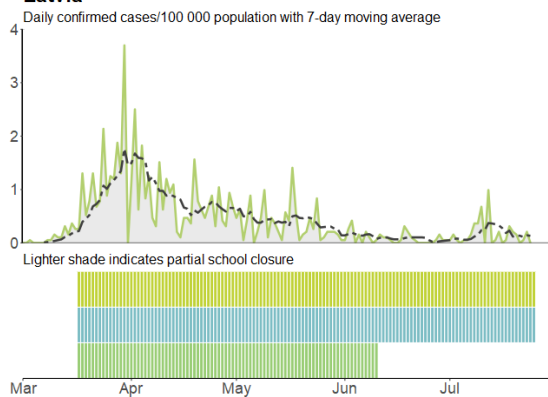
98. Rothe C, Schunk M, Sothmann P, Bretzel G, Froeschl G, Wallrauch C, et al. Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany. *The New England Journal of Medicine*. 2020;382(10):970-1.
99. World Health Organization (WHO). Natural Ventilation for Infection Control in Health-Care Settings 2009 [23 July 2020]. Available from: https://apps.who.int/iris/bitstream/handle/10665/44167/9789241547857_eng.pdf?sequence=1.
100. European Centre for Disease Prevention and Control (ECDC). Heating, ventilation and air-conditioning systems in the context of COVID-19 [Internet]. ECDC; 2020 [23 July 2020]. Available from: <https://www.ecdc.europa.eu/sites/default/files/documents/Ventilation-in-the-context-of-COVID-19.pdf>.
101. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *The New England Journal of Medicine*. 2020;382(16):1564-7.
102. European Centre for Disease Prevention and Control (ECDC). Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2 [Internet]. ECDC; 2020 [cited 23 July 2020]. Available from: <https://www.ecdc.europa.eu/en/publications-data/disinfection-environments-covid-19>.
103. European Centre for Disease Prevention and Control (ECDC). Considerations for infection prevention and control measures on public transport in the context of COVID-19 [Internet]. ECDC; 2020 [23 July 2020]. Available from: <https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-public-transport-29-April-2020.pdf>.

Annex 1. School closures at national level reported from public sources and daily, confirmed cases of COVID-19 over time in EU/EEA Member States and UK, by preschool, primary and secondary school, as of 25 July 2020

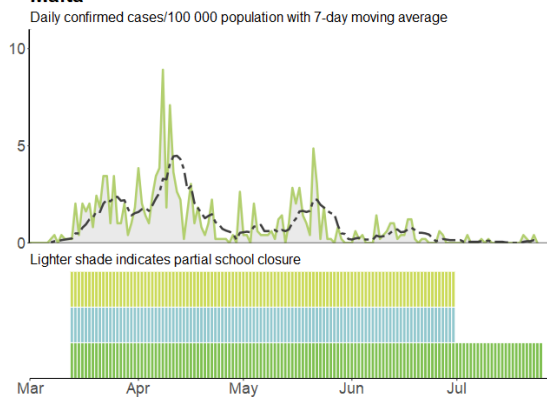




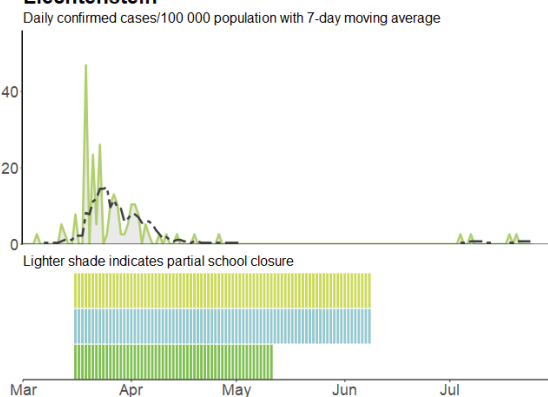
Latvia



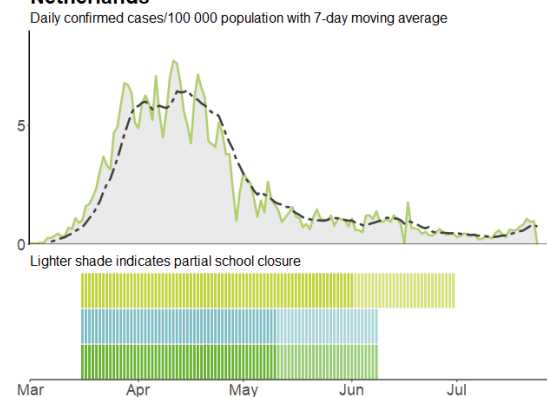
Malta



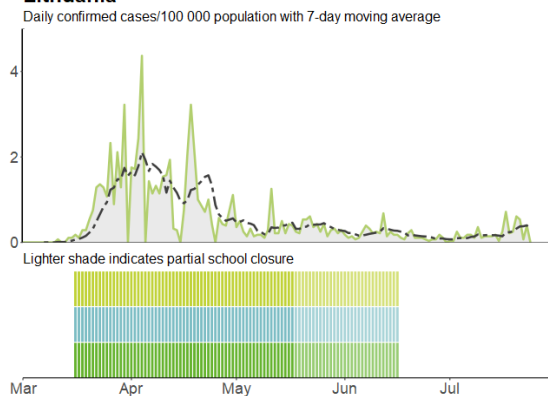
Liechtenstein



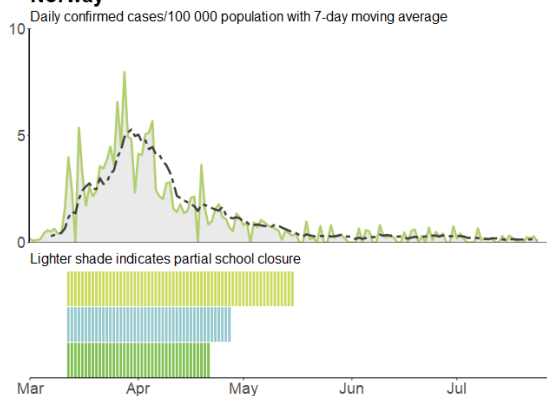
Netherlands



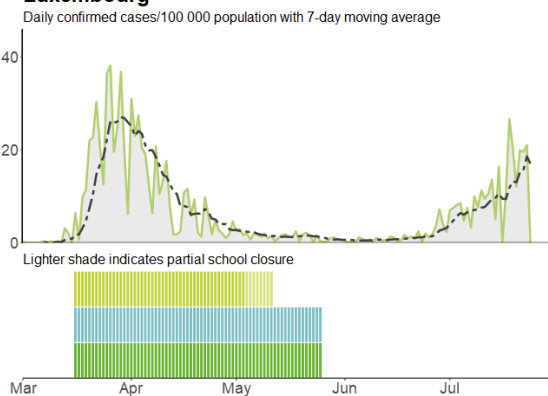
Lithuania



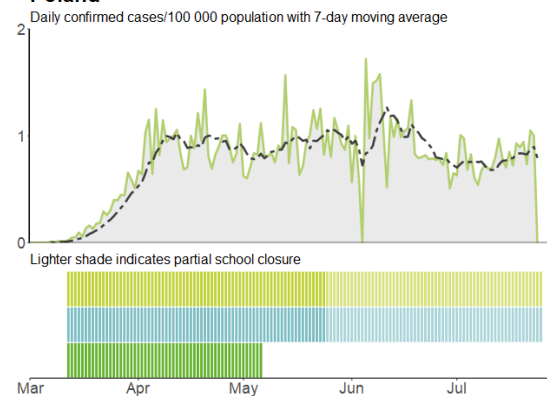
Norway



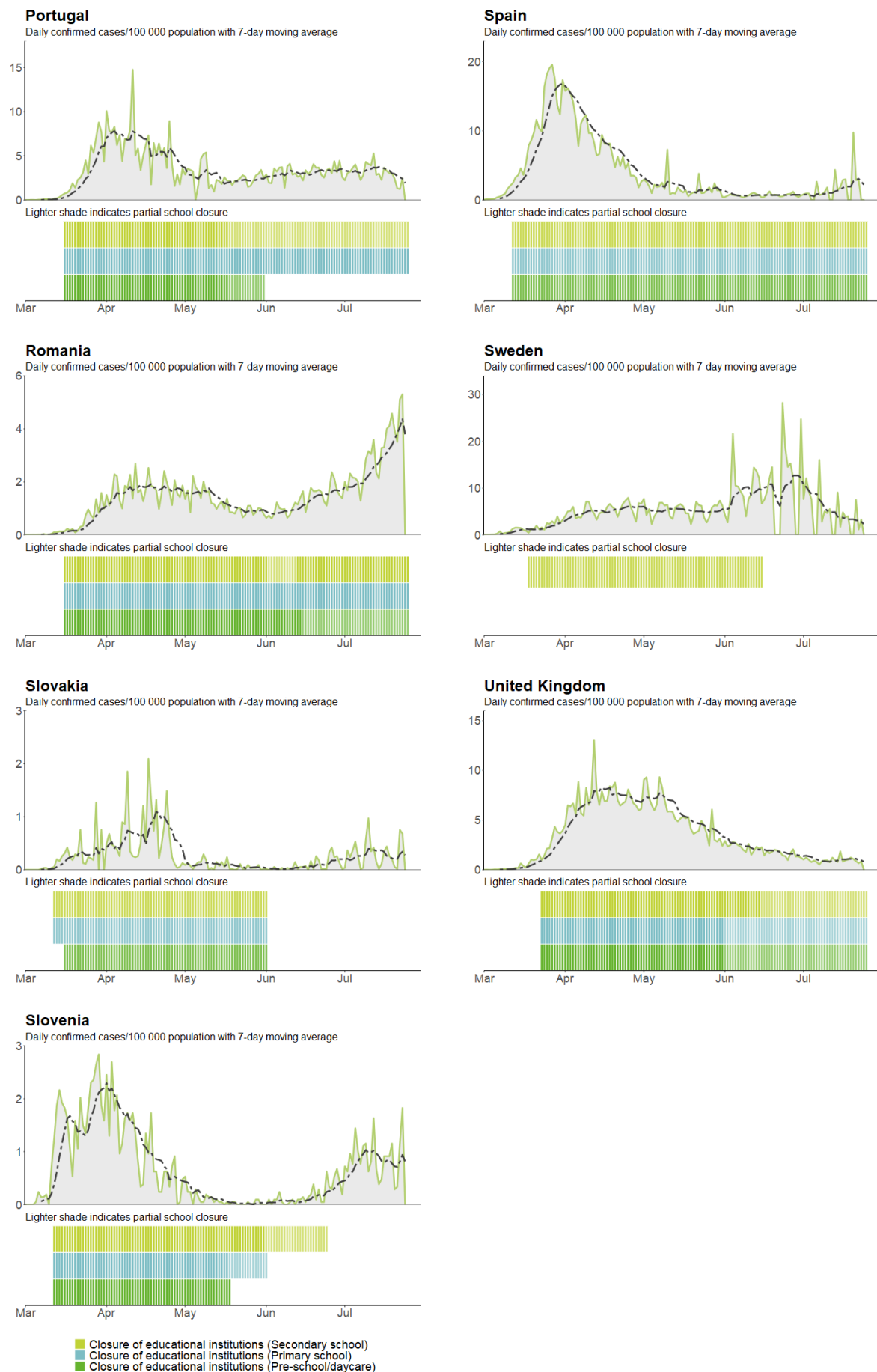
Luxembourg



Poland



■ Closure of educational institutions (Secondary school)
■ Closure of educational institutions (Primary school)
■ Closure of educational institutions (Pre-school/daycare)



Annex 2. Examples of IPC recommendations currently implemented by Member States in schools remaining open and in the planning for re-opening schools

Appropriate infection prevention and control (IPC) measures in the childcare and educational setting are essential to prevent and control COVID-19 transmission and should take into account the needs of children, especially the youngest. The introduction of any measure should follow a risk assessment evaluating the capacity of each school to appropriately implement it, also taking into account the different educational settings, the population groups (children, adults, age groups, vulnerable groups among children as well as among adults) and the local epidemiological data. Based on the risks identified, appropriate non-pharmaceutical and personal protective measures can be introduced, with the aim of ensuring children have access to the most optimal and safe educational and social environment.

Non-pharmaceutical and personal protective measures currently represent the main content of public health advice provided internationally, although only indirect data about their efficacy in mitigating the risk of COVID-19 transmission is available [92].

Physical distancing

Physical distancing is considered to be the most effective measure for reducing the risk of COVID-19 transmission. In childcare and educational facilities, this measure can definitely be considered and approaches implemented to establish it. Measures should furthermore be adapted to the specific age group, taking into account the current knowledge of disease transmission in the age group and the feasibility and appropriateness of the measures for the age group. For example, in Belgium and the Netherlands it is recognised that physical distancing (and the use of masks) is not feasible and/or appropriate for the younger age groups (< 12 years - childcare settings and primary schools) [81].

Clusters and outbreaks of COVID-19 during choir practice and performances [93] or potentially associated with speaking loudly or shouting [94] point towards the need for stricter implementation of physical distancing, avoiding gatherings of children and adolescents and particular activities entailing shouting, such as indoor athletic practice, indoor choir, singing contests or theatrical rehearsals. Other measures to facilitate physical distancing of students, depending on local risk assessment and capacities, include increasing the distance between student desks, decreasing the number of students per class, staggering class starting times, breaks and lunch times. Eating lunch outdoors, if possible, can also be considered, as well as transparent Plexiglas physical barriers at reception or information points and other fixed sites where staff come into contact with large numbers of students (e.g. serving in the canteen).

Use of face masks

When physical distancing is impossible, the use of face masks is recommended in the community. In the school setting, it is challenging to implement this measure, as it is known that children will have a lower tolerance and/or may not be able to use the mask properly [95]. A European standard on minimum requirements for community face masks is currently available from the European Committee for Standardization [96].

A number of countries have introduced the requirement to wear face masks in schools, with variations in recommendations depending on the age groups. Most commonly the requirement to wear a face mask starts in the >12-year age group, with teachers and other staff also required to do the same (Belgium and Czechia). A number of countries have not introduced any requirements for the use of face masks, mirroring the general non-requirement of face masks in the community (Norway, Sweden, the Netherlands).

When taking care of young children, the use of face masks by the caretakers and teachers can stress the children and make them uncomfortable. For this reason, the use of face masks by teachers when taking care of children in kindergartens is not advised in Belgium, for educational and social reasons. The recommendation is the same in Czechia. In primary schools, use of face masks is recommended for teachers and other adults when physical distancing cannot be guaranteed, while it is not recommended for the students. In secondary schools, the use of face masks is recommended for both students and adults.

If a school is served by a health professional (e.g. school nurse) they should have access to appropriate personal protective equipment (PPE) and have received training for its appropriate use while examining students or staff with COVID-19-compatible symptoms. It would also be prudent for the school administrators and the health professionals serving the school to make prior arrangements for referring possible COVID-19 cases to a health facility for testing and/or treatment.

ECDC has published guidance entitled [Using face masks in the community - Reducing COVID-19 transmission from potentially asymptomatic or pre-symptomatic people through the use of face masks](#) [95]. This guidance is available in all 26 official languages of the EU.

Hand hygiene

SARS-CoV-2 is believed to be transmitted mainly via respiratory droplets and by direct contact. However, indirect contact with contaminated fomites is also believed to play a role in transmission. Therefore, frequent and meticulous hand washing and disinfection plays a key role in mitigating the risk of COVID-19 transmission. Rigorous hand hygiene, especially after contact with frequently touched surfaces, before eating, drinking, and after using the toilet, is a measure that will be essential in all school settings and for both children and staff. In all countries within the EU/EEA and the UK, rigorous hand hygiene is considered an essential measure to be implemented.

Respiratory etiquette

Similar to hand hygiene, respiratory etiquette is an essential measure aimed to reduce the risk of COVID-19 transmission. It includes mainly covering of nose and mouth with a paper tissue when sneezing or coughing to help reduce the spread of potentially infectious droplets. Similarly, the use of textile masks or other face coverings can potentially reduce the spread of droplets. Appropriate standards for the creation of textile masks are currently available in Europe [96]. The used paper tissues should be disposed of immediately, ideally into no-touch bins (hands-free), and hands should be washed/sanitised immediately afterwards. The UK "Guidance for full opening: schools" suggest to ensure good respiratory hygiene by promoting the 'catch it, bin it, kill it' approach, in place since the 2009 influenza pandemic. In the Netherlands, children in day care and primary school may attend with cold symptoms as long as they do not have a fever and have had no known contact with a novel coronavirus case [81].

Ventilation

Poor ventilation in indoor spaces is associated with increased transmission of respiratory infections, particularly if confined [97]. Transmission of COVID-19 has been associated with closed spaces, including some from pre-symptomatic cases [61,98,99]. It is therefore important that proper ventilation – preferably with fresh air (i.e. by opening windows and doors) – is practiced, whenever possible, in all the school areas visited by children and adults (e.g. classrooms, corridors, canteen, etc.).

Heating, ventilation, and air conditioning (HVAC) systems may have a complementary role in decreasing transmission in indoor spaces by increasing the rate of air exchange, decreasing recirculation of air and increasing the use of outdoor air when well maintained. It is important that HVAC systems are properly maintained and operated to fulfil their role, according to manufacturer's instructions. In the Belgian and the UK guidelines, ventilation is considered as a key measure.

ECDC has published a guidance document on Heating, ventilation and air-conditioning systems in the context of COVID-19 [100]. This document aims to provide guidance for public health authorities on the ventilation of indoor spaces in the context of COVID-19.

Cleaning and disinfection

The survival of SARS-CoV-2 on different surfaces was evaluated early on in the pandemic, mostly in experimental conditions, which cannot be directly transposed to real-life situations. The environmental stability of SARS-CoV-2 was up to three hours in the air post-aerosolisation, up to 24 hours on cardboard and up to two to three days on plastic and stainless steel, albeit with significantly decreased titres [101]. Due to the involvement of fomites in the transmission of COVID-19, increasing the depth and frequency of cleaning and disinfection of frequently touched surfaces (e.g. doorknobs and door bars, chairs and armrests, table tops, light switches, handrails, water taps, elevator buttons, computer keyboards and screens, touch screens), shared toilets, etc. is considered an important measure when deciding reopening schools.

ECDC has published a guidance on [Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2](#) [102]. This guidance is available in all the 26 official languages of the EU [102].

Transportation to/from school

Crowding in public transport and their use by large numbers of people can contribute to direct transmission of COVID-19 through respiratory droplets and indirect transmission through contaminated surfaces. The use of public transportation or other shared transportation by students and school staff can play a substantial role in the potential transmission of COVID-19. Physical distancing during transport, wearing face masks and cleaning and disinfection of the frequently touched surfaces of school buses should be implemented.

ECDC has published a guidance on [Considerations for infection, prevention and control measures on public transport in the context of COVID-19](#) [103]. This document provides advice on personal protective measures on public transport (including bus, metro, train, commuter boats)

Annex 3. Examples of national and international guidance on school operations during COVID-19

Organisation	Link
Government of Canada	COVID-19 Risk mitigation tool for child and youth settings operating during the COVID-19 pandemic
Danish Health Authority	Materials for reopening day offers
French Association of Ambulatory Paediatrics (AFPA - Association Française de Pédiatrie Ambulatoire)	Retour à l'école - Propositions 2020.
French Paediatrician's Society (Société française de pédiatrie)	Propositions de la société française de pédiatrie et des sociétés de spécialités pédiatriques pour favoriser le retour des enfants avec maladie chronique dans leur établissement scolaire. 2020
French National Academy of Medicine (Académie nationale de médecine)	Mesures sanitaires pour la réouverture des écoles, collèges, lycées et crèches. Communiqué. Académie nationale de médecine; 2020.
French Ministry of Education	Protocole sanitaire. Guide relatif au fonctionnement des écoles et des établissements scolaires dans le contexte COVID-19 à compter de la rentrée scolaire 2020-2021
National Public Health Organisation, Greece	Primary School Instructions (COVID-19)
Norwegian Directorate of Health- (Helsedirektoratet)	Infection protection in kindergartens (covid-19)
Netherlands National Institute for Public Health and the Environment (RIVM)	Children and COVID-19
Portugal	Orientações para a reabertura da educação pré-escolar
Swedish Public Health Authority (Folkhälsomyndigheten)	Covid-19 hos barn och unga
UK government, Department for Education	Getting your school, college or educational setting ready for COVID-19. 2020.
US Centers for Disease Control and Prevention	Preparing K-12 School Administrators for a Safe Return to School in Fall 2020 Considerations for Schools: Operating schools during COVID-19
US National Academies of Sciences Engineering Medicine	Reopening K-12 Schools During the COVID-19 Pandemic: Prioritizing Health, Equity, and Communities (2020)
World Health Organization	COVID-19: IFRC, UNICEF and WHO issue guidance to protect children and support safe school operations

Annex 4. Disease background literature search string in PubMed

The search string used in PubMed is:

("COVID-19"[Supplementary Concept] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept] OR "COVID-19 vaccine"[Supplementary Concept] OR "COVID-19 serotherapy"[Supplementary Concept] OR "COVID-19 diagnostic testing"[Supplementary Concept] OR "COVID-19 drug treatment"[Supplementary Concept] OR "LAMP assay"[Supplementary Concept] OR "Coronavirus Infections"[Mesh:noexp] OR "Wuhan coronavirus"[TW] OR "Wuhan seafood market pneumonia virus"[TW] OR COVID19[TW] OR "COVID-19"[TW] OR "COVID-2019"[TW] OR "coronavirus disease 2019"[TW] OR "SARS-CoV-2"[TW] OR SARS2[TW] OR "2019-nCoV"[TW] OR "2019 novel coronavirus"[TW] OR "severe acute respiratory syndrome coronavirus 2"[TW] OR "2019 novel coronavirus infection"[TW] OR "coronavirus disease 2019"[TW] OR "coronavirus disease-19"[TW] OR "novel coronavirus"[TW] OR coronavirus[TW] OR "SARS-CoV-19"[TW] OR "SARS-CoV-2019"[TW])

Search strategy for literature about Coronavirus in school settings

The search strategy for literature in school settings contained the following keywords: COVID-19, Outbreak, Coronavirus, SARS-COV-2 and various educational setting (daycare, preschool, schools, educational settings, primary school, secondary school, high schools, teachers, pupils, students, educational institutions, universities, adult educational institutions, lecturers).

Relevant publications were identified by searching:

- Targeted websites of national health authorities and universities;
- Generic web search engines (e.g. Google) through customised searches;
- PubMed;
- pre-print servers for non-peer-reviewed scientific manuscripts; and
- Media.

Searches were complemented by hand searches and retrieval of any additional publications that met the eligibility criteria that could be found in the lists of references.

Inclusion criteria:

Studies published on official national websites, in peer-reviewed scientific journals and pre-prints or identified from grey literature and media were included if they described:

- SARS-COV-2 transmission in preschools, primary and secondary schools
- Secondary or tertiary transmission in preschools, primary, secondary schools and households
- Outbreaks in preschools, primary and secondary schools
- Mortality in educational settings
- Modelling of SARS-COV-2 transmission.

Exclusion criteria:

Studies were excluded if they described:

- Transmission in extracurricular activities outside the educational setting (e.g., gym clubs),
- Transmission in young adults (>18 years) in the higher education setting,
- School closure as an NPI on the transmission.

Titles and abstracts identified from searches were screened. Reviewers read the full-text versions of the articles and retained them if they met the inclusion criteria. Data extracted from the included studies comprised: country, authors, year, total number of index children and adult cases, method of diagnosis, number of affected schools, number of cases, number of contact tested, total number of secondary or tertiary cases, etc.